FUMIGATION METHODS

WILLIS G. JOHNSON

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W. G. Johnson

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A Practical Treatise for Farmers, Fruit Growers, Nurserymen, Gardeners, Florists, Millers, Grain Dealers, Transportation Companies, College and Experiment Station Workers, etc.

By WILLIS G. JOHNSON

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ILLUSTRATED

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PUBLISHER'S PREFACE

IT was the original plan of the author to have used as a frontispiece in this work a portrait of Mr. D. W. Coquillett, who discovered the economic value of hydrocyanic acid gas as an insecticide. Mr. Coquillett prefers to be remembered by the discovery he made in his experimental and practical work with hydrocyanic acid gas. The publishers therefore take pleasure in introducing this volume with a portrait of the author, who has done so much to utilize in a practical way the discovery made by Mr. Coquillett.

ORANGE JUDD COMPANY.

AUTHOR'S PREFACE

The radical changes in conditions during the past eight or ten years along agricultural and commercial lines have been followed by the general distribution of many insect pests of a serious character. In commercial transactions the dangers have been so great along certain lines that many State laws have been enacted to prohibit the distribution of such insects as the San José scale and others of a dangerous nature. Some foreign governments have enacted such legislation as to make it practically impossible to ship fruit and nursery stock without the most rigid inspection and fumigation before entry is permitted.

Ability to successfully combat noxious insects is a problem of the most vital importance to farmers, fruit growers, nurserymen, gardeners, florists, millers, grain dealers, transportation companies, merchants, grocers, housekeepers and others. This is especially true of the fruit, nursery, and grain industries. The use of hydrocyanic acid gas and carbon bisulphid, two very powerful insecticides, have largely solved these serious problems. We owe the discovery of carbon bisulphid as an insecticide to M. Doyere, while that of hydrocyanic acid gas belongs to D. W. Coquillett. Their practical application has been one of gradual development.

With the advent of the San José scale in Eastern

nurseries and orchards the demand for exact information about a cheap and reliable remedy became a live topic. Little or nothing had been done with hydrocyanic acid gas fumigation outside of California. From what the writer had observed in California, he was certain that this method was the most promising and would meet the conditions in the East and other places if properly adapted. Hundreds of experiments and practical applications were made by the writer to test the gas in orchards, nurseries, greenhouses, mills, warehouses, granaries, and various other places. The outcome of these tests proved conclusively that hydrocyanic acid gas was a cheap and reliable remedy for a very large range of insects usually found in such places.

In the present volume the writer has attempted to embody the practical results of his own experiences as well as those of others who have used these gases successfully. In his endeavors to gather together the fragmentary notes, scattered as they were in literature throughout the world, the author feels that this work is not complete and perfect in every respect. It embraces, however, for the first time in one volume, a general survey of this important and timely subject.

Where the writer has not given personal credit in the text he wishes to extend the same courteous acknowledgment to all who have in any way contributed to the contents of this volume. Especial thanks are due to Mr. D. W. Coquillett for reading and correcting proofs, and to Mr. Herbert Myrick, Editor and Proprietor of the Orange Judd weeklies and books, through whose aid and courtesy this volume is written and published.

All the illustrations reproduced herewith are from photographs taken by the author, excepting those acknowledged below or credited in the text. To the following the author desires to express his thanks: to the Secretary of the California State Board of Horticulture, for photographs and drawings from which Figs. 8 to 11 inclusive, 13, 30 and 31 were reproduced; to the Director of the California Experiment Station, for permission to use electrotypes of Figs. 14 to 21 inclusive, 23, 45, and 46; to Mr. R. P. Cundiff, Horticultural Commissioner Riverside District, California, for photographs of Figs. 26, 27, 28, and 29; to the Director of the New York Agricultural Experiment Station, for permission to use photographs of Figs. 43, 79, and 80; to the Secretary of the Pennsylvania State Board of Agriculture, for loan of electrotypes of author's photographs; to Mr. D. M. Moore, of Utah, for photograph from which Fig. 62 was made; to Prof. William Lochhead, of the Ontario Agricultural College, for photographs of Figs. 64 and 65; to Mr. W. J. Allen, of New South Wales, for use of Figs. 75, 76, 77, and 78; to Dr. E. P. Felt, State Entomologist of New York, for photograph of Fig. 81, and finally to Mr. C. M. Heintz, editor of the *Rural Californian*, for photographs from which Figs. 82 and 83 were reproduced.

Although the author has taken unusual pains to make this work technically correct yet popular in style, there have, no doubt, crept in some mistakes. When readers note any error, typographically or otherwise, they will confer a great favor on the writer by reporting same, so corrections can be made in future

editions. If this volume will in any way answer the numerous questions asked on the subject of fumigation, either with hydrocyanic acid gas or carbon bisulphid, or suggest methods for future work along these lines, the writer will feel repaid for his labors.

WILLIS G. JOHNSON.

NEW YORK CITY,
February 15, 1902.

FUMIGATION METHODS

CHAPTER I

ECONOMIC USE OF HYDROCYANIC ACID GAS

THE discovery of the value of hydrocyanic acid gas as an insecticide was due to the presence of the cottony cushion scale in the citrous orchards of California. This insect was unwittingly introduced into California from Australia. For a time it seemed certain that the pest would ruin the orange and lemon industry in spite of the concerted efforts of the most intelligent horticulturists to combat it. Despairingly, the growers appealed, as a last resort, to the United States Department of Agriculture for aid. The matter was taken up by the Division of Entomology, and two assistants were detailed by Dr. C. V. Riley, then Entomologist, to undertake the study of methods for the control of the insect. These assistants were D. W. Coquillett and A. Koebele. To Mr. Coquillett belongs the credit of first discovering the value of hydrocyanic acid gas, now so extensively used, for the destruction of insects and other animal pests.

In addition to the detailed account of the gas treatment given by Mr. Coquillett, in the report of the

Department of Agriculture for 1887, and in "Insect Life," Vol. III., by way of explanation, he wrote me March 21, 1898, as follows: "During the summer of 1886 I was employed by the United States Department of Agriculture to carry on a series of experiments at Los Angeles, California, against the cottony cushion scale (*Icerya purchasi*), but owing to an insufficient appropriation I was laid off on August 1st of that year. As no perfect remedy had at that date been discovered, I determined to experiment with gases in a private capacity and at my own expense. Accordingly, during the first week of the following month I began experimenting with hydrocyanic acid gas, which I thought would be the best for the purpose, owing to its very poisonous qualities, the rapidity of its generation, and the readiness with which it diffuses itself in the air. Nobody suggested to me to try this gas. It was not until the following July that the Department of Agriculture again placed me on its rolls."

It will thus be seen that Mr. Coquillett continued to work on the problem of destroying the scale, though at his own expense, and in September, 1886, began seriously to study the methods of fumigation. Fumigation with carbon bisulphide had been inaugurated on a small scale by J. W. Wolfskill and his very able foreman, Alexander Craw, at Los Angeles. At their place Mr. Coquillett began his experiments, profiting by the facilities here provided. It was here he first conceived the idea of using hydrocyanic acid gas. About six months were required to perfect methods.

The result of the work in the Wolfskill orchards

was watched with keen interest by those whose trees were fast being ruined by the scales. Many growers became impatient to know the remedy so carefully guarded by the experimenters. Finally, a number of horticulturists about San Gabriel asked Prof. E. W. Hilgard, of the University of California, for a chemist to experiment in their orchards with various gases. F. W. Morse was detailed for this work, and found, like Mr. Coquillett, that hydrocyanic acid gas was by far the most satisfactory. In the course of these experiments certain parties who had witnessed the former experiments recognized the odor of gas, and thus the secret, so zealously guarded, was given to the public. Although discovered and used by Mr. Coquillett and his associates six months previous to the announcement of Mr. Morse, the first general information about the gas as an insecticide was given to the public by the latter gentleman in a Bulletin (No. 71) from the University of California Experiment Station.

Extensive experiments were continued by Mr. Coquillett. In July, 1887, he was again made an assistant of the Department of Agriculture, and did more than any other person to develop and perfect the present methods of fumigation. The main difficulty encountered in these early experiments was the injurious effect the gas had upon the foliage. The injury was lessened greatly by the "soda process" of Morse, which consisted in adding ordinary baking soda to the cyanide solution, using something like two and a half times as much soda as there was cyanide in the solution, the result being the production of carbonic acid gas, thus diluting the hydrocyanic acid gas.

Speaking of the early experiences with this gas, Prof. C. W. Woodworth says that previous to the time of the publication of Morse's soda method, Mr. Coquillett accomplished a similar diminution of injury by slow generation of the gas. This Mr. Coquillett accomplished by means of a generator consisting of two parts: from one the sulphuric acid passed in a fine stream, regulated by a stop-cock, into the other containing dry cyanide. These facts were clearly set forth by Alexander Craw in a paper before a meeting of fruit growers at Los Angeles, in October, 1887.

The "dry gas process" was soon devised by Mr. Coquillett. It consisted in passing the gas from the generator through sulphuric acid, allowing it to come in contact with the foliage. In this he used a solution of cyanide. This was the situation at the time of the publication of Mr. Coquillett's first paper, cited above, wherein these three processes were described quite fully. He strongly recommended his last process as the cheapest and most convenient; and Mr. Morse, in a later paper, practically abandoned his soda method in favor of the dry gas process.

Injury to trees from the first has been a speculation and controversy, and even now it must be confessed that we are far from possessing sufficient data to enable us to solve any considerable part of the problem. The results have been very uncertain, proving that there are a number of factors involved. One of the earliest explanations suggested was that faulty distribution of the gas would tend to cause burning wherever the pure or slightly diluted gas came in contact with the leaves. Practical experience bore out

this idea, so that in most of the earlier work elaborate provision was made for the mixing of the gas and the air contained in the tent. Generally some form of blower connected with the generator was used. However, later work has demonstrated that this is of minor importance.

The first theory of Mr. Coquillett was that the mixing, or perhaps the combination, of the gas with water rendered it more injurious. Both of his processes were based on this idea. He explained the effectiveness of the soda process as arising from the affinity of the carbonic acid for water. Mr. Morse's original ideas are not made plain in his writings, but his later studies led him to believe that the development of ammonia in the gas was the most important cause of injury. The injurious effects of ammonia are well known, and he demonstrated the presence of ammonia in the gas, especially in that generated from a solution of cyanide. Thus there were two theories accounting for the good effects of the methods then known, and both agreed in favoring the dry gas process. The latter theory seems to have had more foundation in fact, but it soon became evident that there were other still more important factors determining the injury to the foliage.

The successful introduction of ladybirds from Australia into California, and the promising results of the importation, caused the gas method to remain at a standstill for some time. The interest in fumigation was later revived, however, on account of the red scale (*Aspidiotus aurantii*), which was becoming quite troublesome in many orchards in Orange County. By

invitation, Mr. Coquillett took his apparatus to the orchards of A. D. Bishop, and commenced a new series of tests. The ones giving the best results were the same as some of Mr. Coquillett's earliest experiments, in which the gas was generated in a simple generator beneath the tent, according to the formula now generally used.

It was generally believed by Mr. Coquillett at this time that it was the actinic rays rather than the heat rays of the sun that injured the foliage. It had been previously noticed that trees were more injured during the middle of the day than at other times, and it was usually attributed to the heat. Working on his theory, Mr. Coquillett began experiments with a black tent, and confirmed his belief that it was the actinic and not the heat rays that caused the trouble. Naturally, night work in fumigation soon followed. It was on Mr. Bishop's place where the first practical night fumigation was inaugurated. The success of these experiments has been far-reaching. The adoption of methods here perfected has been quite universal. In practical results, the fumigation at night is satisfactory and regarded as essential to good fumigation in citrous orchards. Mr. Bishop, in company with some neighbors, applied for a patent on the process, which was granted, even in the face of a strong protest from Mr. Coquillett and Dr. Riley to the Commissioner of Patents. Later, however, the courts decided that the process was not patentable, and the controversy ended.

The main interests centering around fumigation were confined mainly to California until 1893. In

August of that year the San José scale (*Aspidiotus perniciosus* Comstock) was found at Charlottesville, Va., on the grounds of Dr. C. H. Hedges. This was the first discovery of this pest east of the Rocky Mountains, and naturally caused a good deal of apprehension on the part of fruit growers all over the country. Again Mr. Coquillett was detailed by the United States Department of Agriculture to conduct experiments with hydrocyanic acid gas on these infested trees. The work was begun and completed in March, 1894.

The gas process was not, however, generally recommended for the fumigation of deciduous trees. From the experiences of growers in California I felt certain that the gas could be applied equally as successful to deciduous fruit trees in the East and elsewhere, if properly handled. With practically nothing as a guide, except the general work done in California, and little or no encouragement from leading Eastern entomologists, I began a series of experiments, in the spring of 1897, upon young plum, pear, apple, and nectarine trees. The results of these preliminary experiments were so very satisfactory that I was prompted to continue my work on bearing trees in the fall of 1897. With the aid of Robert S. Emory, of Chestertown, Md., a successful fruit grower, we perfected an outfit and completed the first successful fumigation of a large orchard in the East. The results of this work were watched with much interest in this and other countries. While the methods of generating the gas have not been materially changed, the amounts of chemicals have been adapted to suit conditions. The apparatus for containing the gas has been improved,

and the box system, designated by me as the "Emory Fumigator," has been perfected, and is now commonly used by orchardists and others.

Since 1894 the gas has also been used in greenhouses for the destruction of certain pests. The demand for fumigated trees led me to conduct an extensive series of experiments with the gas upon nursery stock of various kinds and grades. These tests, begun the fall of 1896 and completed the spring of 1899, have shown conclusively the maximum and minimum amount of gas young trees will withstand without injury. Many obscure points about the construction and management of fumigating houses have been made clear.

In 1898 I first suggested the use of hydrocyanic acid gas as a remedy for the destruction of insects in mills, elevators, and warehouses. The system has since been perfected under my direction, and it is now in general use in this and other countries. In 1900 I demonstrated that the gas could be used in tight buildings with perfect success and safety, even in the thickly populated districts of a city, when properly handled, for the destruction of certain pests, including rats and mice. The fumigation of street-cars and railroad coaches to destroy bedbugs and other vermin is commonly practiced in many places. The gas is also employed to rid houses of undesirable pests, but in such cases should be handled with great care.

CHAPTER II

HOW THE GAS IS MADE

THE chemicals used for generating hydrocyanic acid gas are (1) fused cyanide of potassium (KCN), (2) sulphuric acid (H_2SO_4), and (3) water (H_2O). The cyanide should be guaranteed 98–99 per cent., which is practically chemically pure. There is upon the market in some places an old brand of cyanide of about 58–60 per cent. purity. This should be avoided.

The best grade of commercial sulphuric acid, with a specific gravity of at least 1.83, should be used. A grade known as chamber acid used ordinarily in the manufacture of fertilizers will not do, and under no circumstances should it be employed. Water from any source will suffice, the only requisite being that it should be clean.

In combining the chemicals (1), measure the acid in the glass beaker marked ounces on the side, and pour it in an earthenware crock, wooden bucket, tub, or pickle jar; (2), measure the water in the same beaker and pour it on the acid; (3), drop in the cyanide, bag and all, if wrapped in paper, close the door or drop the tent quickly, and leave desired length of time.

Action of the chemicals.—When the water is poured into the jar upon the acid, a slight evolution of steam arises, which is not dangerous. As soon as the cyanide is dropped in the acid and water there is a bubbling

and sizzling similar to that produced by a piece of red-hot iron in cold water. There is also a dense cloud of so-called steam given off. This bubbling is due to the action of the acid on the cyanide, and the so-called steam is the gas being produced. The result of this chemical action is the production of hydrocyanic acid gas (HCN), known in the liquid form as prussic acid, according to the following equation: $2KCN + H_2SO_4 = 2HCN + K_2SO_4$. The gas has an odor somewhat similar to that of peach pits, but do not stick your nose over a vessel in a house or under a tent to test it. These fumes, if inhaled, would prove fatal, and thus the necessity of great care.

The vessel.—Various kinds of vessels can be used for the acid and water. Usually an ordinary earthen jar, china dish, or bowl is used. In some cases a wooden pail or tub can be used to good advantage. As a rule, earthenware vessels are employed in orchard and nursery fumigation. The size of the vessel will depend upon the amount of material to be used for generating the gas. Sometimes in mills, warehouses, elevators, and other enclosures large jars or wooden pails containing from two to three gallons are necessary. Under no circumstances should tin or iron vessels of any kind be used, as the acid would quickly corrode and ruin them. For small boxes a china bowl or tea-cup can be used.

Residue in the jar.—After a charge of gas has been liberated there will be a residue left in the jar. At first, and while still warm, it is a whitish liquid, with a bluish cast, but as it cools it becomes thick like paste

and crystalizes when cold. It is easily soluble in water. Immediately after the room, tent, or other inclosure has been ventilated the desired length of time the contents of the jar should be emptied on a manure pile, in a hole prepared especially for that purpose, or under the tree close to the trunk. As the acid and potash left behind are both excellent fertilizers they should be saved by composting them either with manure or dirt. The residue consists of sulphate of potash, sulphuric acid, and water. The sulphuric acid will unite with lime in the soil, forming gypsum. Never pour the residue in an exposed place, where a person would be liable to step in it, or where a tent can be dragged through it.

No dangerous deposit formed.—The question is often asked about the possibility of hydrocyanic acid gas forming a deposit upon any of the substances with which it might be brought in contact in its ordinary use as a fumigant, either in greenhouses or in buildings infested by indoor insects. Dr. H. W. Wiley, chemist of the United States Department of Agriculture, states that there is no possibility whatever of such a contingency, unless the gas comes in contact with some alkaline body, such as soda or potash, with which it would form a salt. The soluble cyanides are extremely poisonous, and if this gas were to act upon lye, or any similar alkaline body, a certain amount of cyanide would be produced. *In a dry room, in the absence of alkaline bodies, there could not be any possible danger of a poisonous body being formed.*

CHAPTER III

PHYSIOLOGICAL EFFECTS ON PLANTS

As noted in a previous chapter, early experimenters had observed the burning effects of the gas upon foliage when used under certain conditions and overcome the difficulty by night fumigation. It remained for Dr. Albert F. Woods, now Chief of the Division of Vegetable Physiology and Pathology, United States Department of Agriculture, and an assistant, P. H. Dorsett, to solve this problem in connection with certain greenhouse plants. In 1894 they began a series of experiments, and proved conclusively that plants are less injured by a short exposure to a relatively large amount of gas than by a long exposure to a relatively small amount, and also that a stronger dose a short time was more destructive to the insects affecting the plant. They further demonstrated the physiological effect of the gas upon the plants by subsequent experiments. They summed up the resisting power of the plant as dependent largely upon the open and closed condition of the breathing pores of the leaf, the peculiarities of the cell contents, and the temperature of the inclosure.

I found the same variations in the field, where we used the gas largely in the control of San José scale and other insects. The first problem taken up in this connection was the physiological effect of the gas upon deciduous trees in the East. The conditions in

Eastern orchards were quite different from those in California. With our experiments we did not begin with the deciduous trees until the function of the foliage had been performed, namely, late in the fall, just previous to the heavy frost. These experiments were conducted in late September and early October. It made little or no difference to us whether we scorched or burned the leaves; our main point was to determine what effect the treatment was going to have upon the fruit or leaf development for the following season.

The next practical application of the gas was its use for the fumigation of nursery stock. As no precise experiments had been conducted in the East, the writer began a series in March, 1897, upon young apple, peach, nectarine, plum, and pear trees. They varied in hight from four to five feet, were thoroughly dormant, and badly infested with the San José scale. They were placed in a room 4 x 7 x 7½ feet, prepared for the purpose. A general, miscellaneous lot were exposed thirty minutes in gas generated from 0.20 gramme of cyanide of potassium per cubic foot of air-space inclosed. Another lot was exposed to gas from 0.20 gramme up, through the series formed by adding 0.05 gramme each time, until 0.50 gramme was reached. All the trees of these lots were observed very closely for two years. No injury was noticed, and not a living scale was ever detected upon them. The cyanide used in these experiments was the 98–99 per cent. pure, while that used at first in the California orchards was the old 58 per cent.; this must be taken into account when considering the effects of the gas on trees and amounts of chemicals used.

Orchard experiments.—In the fall of 1897 I began, perhaps, the largest series of experiments ever undertaken in the East for the destruction of San José scale. The orchard chosen was a nine-year-old Bartlett dwarf-pear in full foliage. Canvas tents were used. The trees were fumigated at all hours of the day and under varying conditions of weather. We had sunshine, cloudy and foggy days, rain, sleet and snow, windy and calm weather. In one series, September 29th, with a temperature of 70° F., we used 0.40 gramme cyanide per cubic foot instead of 0.20, as in most of our experiments. The leaves on all the trees were very brown, in fact, almost black. Within five minutes after the tents were removed the petioles were black almost to the base; the leaves fell a few days later. The following spring the leaves came out as normally as on any other trees in the orchard where no fumigation occurred. There was about one-quarter as much fruit on these trees, however, as upon those that had been fumigated with the normal strength, that is, 0.20 gramme. Other trees were treated at night with the same double dose, at a temperature of 58° F. The foliage, the first week, showed no injurious effect whatever, and remained just as green as on trees not fumigated. The eighth day, however, the leaves began dropping, and a few days later were all off. The leaf buds came out the following spring, but the fruit was only about half as abundant as on surrounding trees. The double dose, it would therefore seem, is injurious at least to the fruit buds of Bartlett pear under such conditions.

The final outcome of the whole series of experi-

ments showed that gas was most injurious to foliage on sunshiny days late in the fall between 9 A.M. and 4 P.M.; that the dormant leaf and fruit buds treated with 0.20 gramme cyanide per cubic foot were not injured; that burned leaves, that is, those injured by the gas, fall readily; that trees treated in the morning before 9 o'clock and in the afternoon after 4 o'clock, even in sunshine, have the leaves little affected; that trees treated at night with normal doses do not have the foliage hurt at all.

On March 18, 1898, experiments were begun upon plum trees, using the same standard dose, just as the buds were unfolding, and observed no injurious effects whatever. June 3, 1898, eight young plum trees, from 8 to 10 feet in hight, were fumigated with 0.16 gramme cyanide. The exposure varied from 5 to 12½ minutes, in the sun at 80° F.; in every instance all the lice were killed and the foliage not injured. July 8, 1898, three cherry trees were fumigated with 0.16 gramme cyanide from 5 to 10 minutes. The trees were infested with the cherry slug. A five-minute exposure did not injure the foliage at all, but did not destroy over 60 per cent. of the slugs; on the other hand, 7½ to 10 minutes destroyed all the slugs, but severely hurt the leaves. June 13, 1898, two pear trees, badly blighted, were fumigated with 0.20 gramme cyanide per cubic foot, for 6 and 10 minutes respectively. We could see no bad effects on the leaves and no decrease in the blight. In April, 1899, after the buds had begun to open, some experiments were completed, using 0.20 gramme cyanide, upon pear trees. The former tests had been made during

the fall, midwinter, and early spring, and now we took up the effect of the gas on the trees in late spring as the buds began to open.

Work upon nursery stock.—Experiments were also performed the spring of 1899 upon nursery stock, for the purpose of determining the precise effect of the gas upon young trees used at a strength greater than 0.25 gramme cyanide per cubic foot. Owing to the fact that some states stipulate by law that trees must be fumigated, it became absolutely necessary that we know definitely the effect of this gas upon growing plants, especially dormant trees. No recent experiments have been recorded along this line, as far as I know. We have been using 0.25 gramme cyanide in general work, and I recommend that strength for all nursery stock above three feet in hight.

Apple trees.—We began our experiments with the stronger doses March 29, 1899. The apple trees were divided into twenty different lots of five trees each, leaving five for a check. They were 4 to 5 feet in hight, and of the following varieties: Ben Davis, Northern Spy, Limbertwig, Wealthy, Fall Pippin, Oldenburg, Stark, Rome Beauty, Schockley, and York Imperial. They were exposed in gas one hour, and each lot was fumigated with 0.25, 0.30, 0.40, 0.45, and so on, adding 0.05 to each one until we reached 1.00, then skipped from 1.00 to 1.25, 1.35, and 1.45 grammes, thus completing the series. The trees were labeled and planted, and were under observations two seasons.

The outcome of these experiments is as fol-

FIG. I—YORK IMPERIAL APPLE TREE, FUMIGATED WITH SIX TIMES NORMAL STRENGTH OF GAS AND NOT INJURED

lows: I had fully expected that the gas would badly injure the trees above 0.75. In fact, no apple trees were injured in the least, even when exposed to 1.45 grammes, or about six times the normal strength,

FIG. 2—OGON PLUM TREE, FUMIGATED WITH THREE TIMES NORMAL DOSE

excepting one variety, Northern Spy. I can not explain why this was more susceptible to the gas in this test than the others, as it is naturally a hardy tree, and its resisting properties should be as great as Ben Davis or any of the other varieties treated. The

condition of the Spy in general appearance was about the same as the others, and the buds had just begun to swell. The injury, evidently, was not due to the gas, as subsequent tests with normal doses showed that no injury to Northern Spy resulted.

Figure 1 shows one of the York Imperial apple trees in this experiment, fumigated an hour in gas representing nearly six times the normal strength. The photograph was taken July 31, 1899. The growth was good and the tree was in perfectly normal condition when the experiment was closed.

FIG. 3—OGON PLUM TREE, FUMIGATED

Plum trees.—Twenty plum trees of the following varieties were fumigated April 17 and 18, 1899: Abundance, General Hand, Genii, Lombard, Ogon, Shipper's Pride, and Spalding. The trees varied in hight from 2 to 4 feet. Each lot had one hour's exposure, with 0.35, 0.45, 0.55, 0.65, 0.75, 1.25, 1.35, and 1.45 grammes of cyanide. The results obtained are very striking; for instance, there was no damage whatever to any varieties until 0.65 gramme was reached, when the Spalding had terminals slightly injured, while General

Hand was not hurt. At 0.75 gramme Ogon had terminals slightly injured, as shown in Fig. 2, while Spalding was killed to the ground, but later sent out shoots at the base. At 1.00 gramme Ogon was again only slightly hurt, while Abundance was dead to the surface of the ground. From 1.00 to 1.35 Ogon was slightly injured on the terminals, as can be seen in Fig. 3.

The general conclusions drawn from these tests with plum are (1) that no injury will result where normal dose is used for one hour or less on well-matured trees over two feet in hight, and (2) that some varieties are more resistent to injury from over-doses of gas than others.

Peach trees.—The experiments upon peach trees were commenced April 26, 1899, after the buds had begun to swell. There were 250 trees, one-half of which were first-grade Peninsula Yellow, 4 to 5 feet, while the others were very small, varying from 1½ to 2 feet high. The trees were divided into lots of five each, and both grades treated from 0.25 to 1.45 grammes cyanide per cubic foot, 0.05 gramme being added each time. In every instance the short grade trees, known as "whips," were killed outright, or the tops were killed, sending out few feeble shoots near the ground later. This corresponded to results obtained in 1898, that June-budded peach and plum, and small whip-like trees from 1½ to 2½ feet, can not withstand more than 0.18 gramme for half an hour. On the other hand, with large trees there was no perceptible injury from 0.25 gramme up to 0.50 gramme. At the latter strength, double the normal, the terminals were injured

FIG. 4—PEACH TREE, FUMIGATED WITH NORMAL DOSE

slightly, as shown in Fig. 5, while a tree given a normal dose, 0.25 gramme, is seen in Fig. 4. In 0.75 gramme the top was killed about one-third the way down, as seen in Fig. 6. The engravings are self-explanatory, and show the deadening effect with the varying degrees of gas from the top downward. From 0.75 gramme to 1.00 gramme it was variable. In some instances the whole top was killed. From 1.00 gramme up to the highest amount used, 1.45 grammes, a curious fact was noticed. In almost every case the injury was not as great above 1.00 gramme as below 0.75 gramme. In 1.35 and even 1.45 the trees were only slightly injured at the top, as seen in Fig. 7, resembling the effects produced where 0.50 gramme was used.

June-buds, grafts, and buds.—Young peach and plum trees, known as June-buds, should not be fumigated with the stronger doses. Tests made in 1898 show that nursery stock of this kind will not withstand the gas when generated with cyanide above 0.18 gramme per cubic foot. Any wood not well matured is liable to be injured if a greater amount of cyanide is used. For stock of this character 0.16 to 0.18 gramme cyanide per cubic foot is recommended, at an exposure of one-half hour and no longer. The scale, under ordinary circumstances, is destroyed when fumigated with 0.12 to 0.14 gramme cyanide. The 0.15 to 0.18 formula can be used with perfect safety on buds, grafts, and scions.

Roses and other supplies.—In fumigating roses and other materials handled by florists the cyanide should

FIG. 5 FIG. 6 FIG. 7

VARYING EFFECTS OF GAS ON MATURE PEACH TREES WHERE OVERDOSES WERE USED

be reduced to 0.10 to 0.15 gramme cyanide. As a rule, it is not desirable to fumigate such plants as cedars, pines, etc.

Seeds of various kinds can be fumigated in normal amounts of gas with perfect safety, the varying physiological effects depending upon the condition of the grain or seed, whether dry or moist, upon the amount of gas used, the length of time exposed, and the atmosphere in which it is confined, whether dry, damp, or saturated. This is treated more fully later in another chapter.

Low-growing plants may be fumigated for the destruction of the root aphis, leaf-rollers, and other insects, but the work must be done with the same care as for other plants. Lettuce, cucumber, and cantaloups are very easily injured if the plants are damp, even with small amounts of gas. In tests made by Professor E. D. Sanderson, of the Delaware Agricultural Experiment Station, upon young cantaloups after a shower, he found the plants were injured in 0.40 gramme of cyanide per cubic foot for ten minutes. Preliminary tests should be made with 0.10 to 0.20 gramme for ten to twenty minutes before an entire house is exposed. Professor Sanderson has shown also that strawberry plants freshly dug and fumigated in a box will withstand 0.20 gramme cyanide fifteen minutes. His tests show that this strength will kill the aphids on the roots and not injure the plants. Other details are given in a later chapter on this topic.

CHAPTER IV

EFFECTS ON ANIMAL LIFE

OWING to the very deadly nature of hydrocyanic acid gas if inhaled by animals, the following instances are given as a warning to those who may handle this material.

A fortunate accident happened in a fumigating house which should be a signal warning to those who may use this gas. The house had been filled with Norway maple trees, and after the usual length of time the doors were thrown open. At the expiration of seven minutes a negro laborer, who had been repeatedly warned not to enter the room under ten minutes, went in and began handing out the trees to another negro standing at the door. He handed out two bundles, and while stooping for the third fell headlong on the floor. He was immediately pulled out, laid on his back in the open air, recovered consciousness in about fifteen minutes, and was seemingly as well as ever in half an hour. When asked what had happened and how he felt, he replied, "De Lord only knows dat stuff am a powful axfitter!"

Another peculiar accident happened during our experimental operations at Mr. Emory's. Our cyanide having been shipped to us in lumps too large for use, we found it necessary to break it up in smaller pieces. In order to do this and keep it from flying, we covered it with an old fertilizer bag. After the cyanide had

been removed from the bag and the smaller particles shaken out, the bag was again shaken out the window to free it of any particles that may have remained. As a result, a few small pieces, not larger than a pin's head, were shaken on the ground. Two fine, large chickens, especially prized by their keeper, roaming about, picked up some of the cyanide, and in less time than it takes to write this account they were on their backs. One died in a very few moments, while the other recovered, evidently not having gotten so much.

Professor Woods tells me that a favorite cat, asleep under a bench in one of the greenhouses he fumigated, was killed without being awakened. A dog was placed in one of our fumigating houses to test the effect of the gas upon animal life, after the room had been opened and aired for seven minutes, and again closed. The animal was removed after five minutes' exposure in an unconscious condition, but recovered in half an hour.

Frequently the writer has placed toads, frogs, snakes, pigeons, sparrows, rats, mice, dogs, and cats in some remote corner in buildings to test the thoroughness of the diffusion of the gas. In every case the animal was dead when removed. Many instances could be cited, but this will suffice our purpose in warning those who use cyanide or hydrocyanic acid gas that they are exceedingly dangerous substances and *must be handled carefully*.

CHAPTER V

APPARATUS FOR USE IN ORCHARDS

THE equipment necessary for orchard fumigation depends largely upon the kind of trees to be treated and the location of the orchard. In California the sheet tent is in general use. Another form, known as the bell tent, is also quite commonly used in California orchards. Of the earliest apparatus used, the Wolfskill fumigator was a good type. It is a bell tent manipulated by a derrick mounted on a wagon. It has an arm on each side extending over the top of the trees when driven between the rows. This form of tent is lifted up by means of a rope attached to the top and extending to a loop at the end of the arm or derrick, through which the tent is drawn as it is removed from the tree. This form of tent is shown in Fig. 8.

Another form, known as the Titus fumigator (Fig. 9), consisted of a smaller tent, supported by a square frame braced at each corner and mounted on wheels with a piece across the top, on which the tent could be wound in removing it from the tree. Still another form, known as the Culver fumigator (Fig. 10), consisted of two light frames, half-bell shaped, covered with cloth. It formed a complete tent when closed together around the tree. This form of fumigator was simplified later and the cloth allowed to rest on the sides of the tree. The Culver outfit, in con-

nection with the Morse fumigator, is shown in Fig. 11. All the earlier forms of fumigators were provided with generators and blowers. They have all been superseded by different forms of tents better adapted for orchard work.

To meet the general conditions in the East and other places, I have perfected still another form, which has been called the Emory fumigator, and is shown in Figs. 32 to 35. On large orchard trees the sheet tents are better adapted for general work than the box tents. The Emory fumigator is especially adapted for trees under ten feet in hight.

The canvas or sheet tent.—The octagonal form known as the sheet tent has been used largely in California and by the United States Department of Agriculture. The size of these tents depends upon the size of the trees to be fumigated. Sheets from twenty-five to forty feet and over in diameter are in common use. One tent used in my experiments was forty-five feet in diameter and was used only on large trees. Another canvas tent, made in several sections with a square top and base, designed by R. S. Emory, is shown in Fig. 12. These tents vary in size to meet the requirements under different conditions in various orchards. A very convenient size of canvas-box tent is fifteen feet square at the bottom, ten feet square at the top, and fifteen feet high. Occasionally tents of this same design of much smaller dimensions are used, but they are not generally recommended.

Construction of tent.—All tents now in general use are usually made of eight-ounce cotton duck, such as

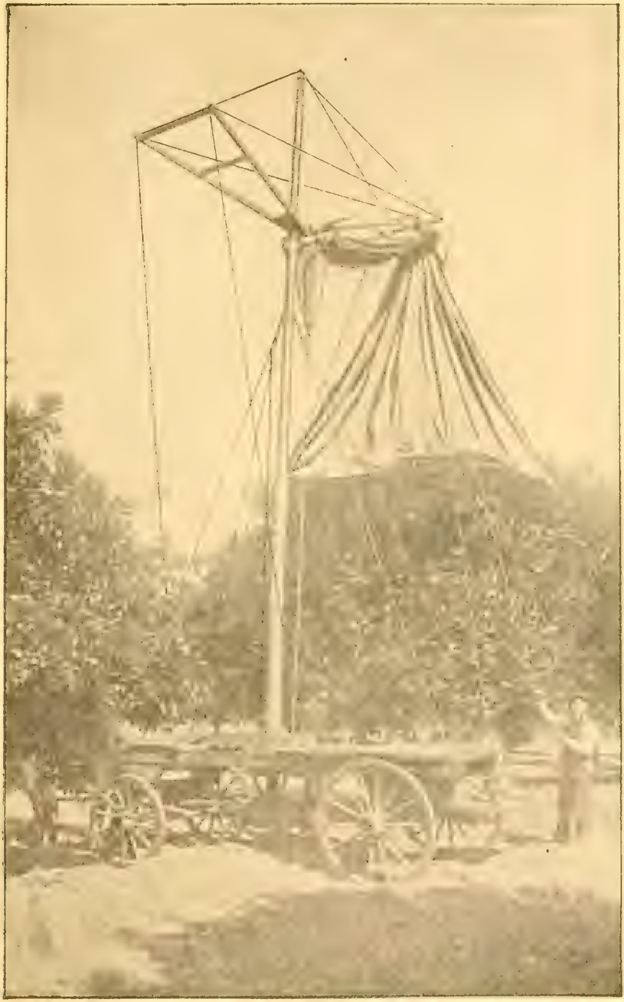

FIG. 8—THE WOLFSKILL FUMIGATOR

is used by the Army and Navy for tents and light sails. With little care any awning or tent maker can cut the sheet tents so there is practically no waste in material. They are usually cut and made into quadrants and then put together. The center in the large tents is usually

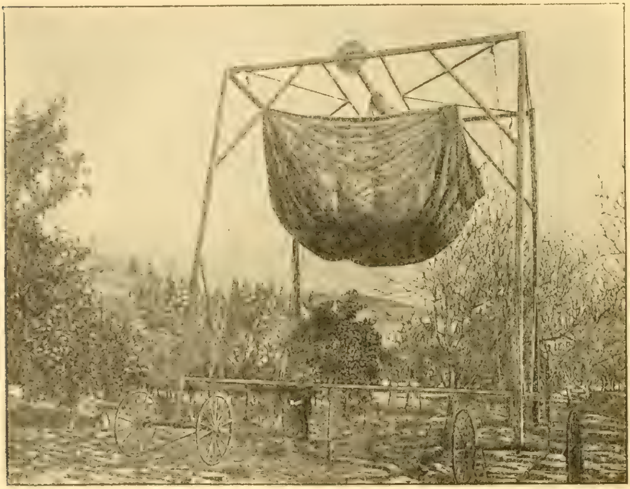

FIG. 9—THE TITUS FUMIGATOR

double for a space of about two feet in diameter, as there is considerable strain upon the material at this point. A half-inch or five-eighths inch rope should be hemmed in around the edges.

The cost varies according to the size, and the expense of oiling must be added. All tents should be thoroughly oiled by painting them with boiled linseed oil. Usually one or two coats will be sufficient. The

following quotations, including oiling, were secured from a Baltimore, Md., tent-maker:

Sheet tent, with square top and base,	4 x 5 x 2 ft. . .	$2.00
" " " " " " "	7 x 10 x 4 " . .	7.00
" " " " " " "	10 x 15 x 15 " . .	12.50
" " octagonal form, 25 ft. in diameter	. . . .	18.00
" " " " 30 " "	. . . .	25.00
" " " " 45 " "	. . . .	42.00

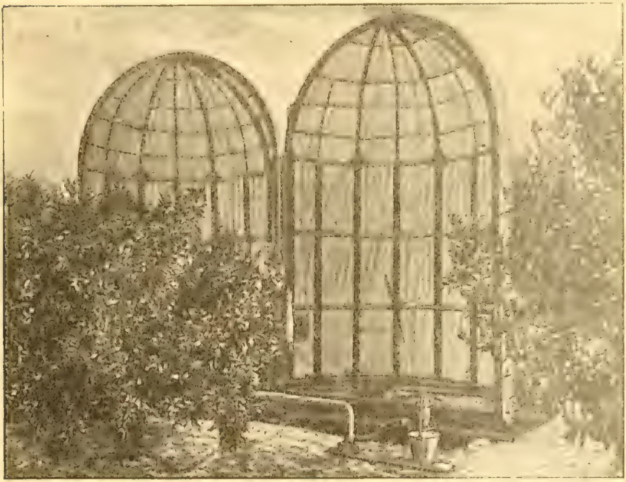

FIG. 10—THE CULVER FUMIGATOR

In constructing tents the cloth is lapped and doubly sewed in the same manner as for tents or sails. The edge can be either hemmed or bound with rope. If permanent rings for handling are attached the tent may need reinforcement. The general details of the

construction depend somewhat upon the persons doing the work.

Oiling and painting.—In order to make a tent gas-tight it is necessary to cover it with oil, paint, or other material. Several methods are in general

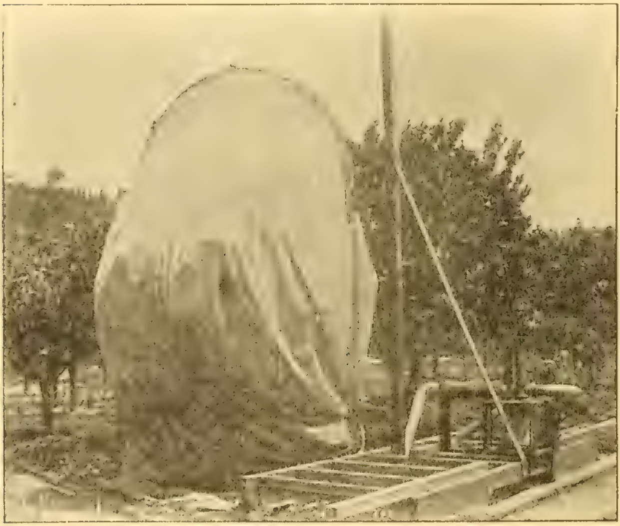

FIG. 11—CULVER TENT AND MORSE FUMIGATOR

use for this purpose, all of which have been used with considerable satisfaction. A free application of boiled linseed oil is, perhaps, the method most commonly used. After the tent is thoroughly saturated with oil it should be spread out or tacked to the side of a building where it can dry. Care must be

taken that the oil is thoroughly dry, otherwise it has a great tendency to generate heat if the tent is folded and left for any length of time. The cloth burns or

FIG. 12—CANVAS TENT WITH SQUARE TOP AND BASE

chars and is ruined. On the other hand, if the tent is thoroughly dry after oiling, it is easily handled and can be folded with perfect safety.

In some cases paint is used. It is applied with a brush in the same manner as the oil and penetrates the

cloth, filling the fiber in the same way, making it when dried thoroughly gas-proof. As soon as the paint is dry the sheet is covered with another coat of rather flexible paint. When dry this coating makes a perfectly tight tent, with a smooth surface and quite as flexible and easily handled as the oiled tent.

Still another method is used in some places. A decoction is made by filling a barrel two-thirds full of chopped stems and leaves of the common prickly pear cactus (*Opuntia engelmani*). Afterward the barrel is filled with cold water and is allowed to stand twenty-four hours. The liquid is then drawn off and ready for use by adding a pigment, like yellow ochre or Venitian red. Sometimes a small quantity of glue is added. To prevent molding when not in use and folded, a small quantity of tannin solution is added to the mixture. This solution can be applied to the tents with a brush, but where a sufficient quantity is on hand it is better to soak the sheets over night in a vessel containing the mixture. They should then be taken out of the material, thoroughly drained, and spread out to dry. This method, however, is not generally used, but has given very satisfactory results, as the cloth is not stiffened, and is made quite flexible and easily handled.

CHAPTER VI

BELL AND HOOP TENTS

THE tents known as bell tents are cylindrical in shape, with the top rounded over like a dome. They are used in connection with a derrick, by means of which they are placed upon and lifted from trees; the derrick also supports the weight of the tent while it is upon the tree. The bell tent was one of the original forms of tents, and while mostly supplanted by other styles, is still used to a considerable extent, especially for very large trees. It is the only form of tent now in use where the whole weight of the tent is not carried by the tree, and many favor it for this reason.*

The derrick used with the bell tents at the present time is that used with the Preble fumigator, or some modification of it. This is shown in Fig. 13. It consists of a wagon, which supports a mast considerably higher than the trees to be fumigated, and is braced at the bottom with stays that hold it rigidly in place. Across the top of the mast a yard is fastened and braced with trusses extending from the mast. The length of the yard is about a third longer than the distance between the rows of trees. Near each end of

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* This description is taken from the excellent bulletin (No. 122) by Prof. C. W. Woodworth, of the California Experiment Station.

the yard are placed cross-bars, as shown in the illustration. The arrangement of the ropes can be understood from a study of the figure.

The heaviest rope is attached to the top of the tent with double pulleys. Along the lower edge, on the

FIG. 13—THE PREBLE FUMIGATOR, AS USED IN CALIFORNIA ORCHARDS

four sides of the tent, are fastened boards, generally of ordinary six-inch fencing, which are called trail boards, and from the center of each of these the trail ropes pass upward and over pulleys attached to the yard and ends of the cross-bars. All these ropes follow the yard till near the mast, then passing again over pulleys, they go down to the bed of the wagon and are fastened over belaying-pins. The trail ropes pass

through thimbles along the side of the tent as well as through the pulley at the center of the trail, so that when the latter is drawn up to the yard, or cross-bars, the sides of the tent are gathered in three or four places and raised almost as high. The only other ropes are the guide lines attached to the center of the

FIG. 14—RAISING SMALL HOOP TENT

trails and hanging free. They are of such length as to reach the ground when the tent is elevated.

The manipulation of these tents can be readily understood from a study of the engraving. While the tree is being fumigated the tent is usually allowed to rest partly on the tree and not drawn up to the yard, as shown in the illustration. Two persons can handle the apparatus, but three or four greatly facilitate the work. The procedure in changing the tent is

as follows: Supposing that both tents are upon the trees and the time has arrived to make the change, the first operation is to pull on the main rope attached to the center of the tent and raise this as far as it will go easily, and then fasten the rope again to the belaying-pin. If short-handed, one tent is raised at a time,

FIG. 15—SMALL HOOP TENT ALMOST IN POSITION

but with plenty of help both go up at the same time. The trail ropes are next taken in hand and pulled all together, and if this becomes difficult, two (or even one at a time) are pulled until the tent on all sides is pulled up to the yard and cross-bars.

While this is going on, one person (or perhaps more) is kept busy seeing that the tent is clearing the tree properly. His first business is to see that the

edge with the trail boards is not caught inside of the tent; it should slip up around outside of it. Later he will be occupied with making the tent slip off the projecting branches. He can generally do this by pulling on the guide lines, but on very large trees he may find a light ladder necessary. The removal of the tent

FIG. 16—SMALL HOOP TENT READY FOR CHEMICALS

would be comparatively easy but for the work at the ropes. After all the ropes are pulled tight, including the main rope, and both tents are against the yard, the apparatus is ready to shift to the next row. The wagon may be pulled along by hand, or by a horse hitched to the end of the tongue. If the ground is a little uneven, the apparatus can be kept from tipping over by steadying it with the guide lines. Arriving

at the proper position between the next two trees, the first thing is to arrange the guide lines in their places around the tree. The trail ropes are now released and the tent is allowed to slowly descend upon the tree. While this is taking place, one or more are busy with

FIG. 17—LIFTING LARGE HOOP TENT FROM GROUND

the guide lines, pulling the trail boards this or that way as may be necessary to clear the branches.

If a branch is particularly spreading it may be necessary to use a ladder, forcing it within the tent by hand. Should the trees be very large the branches will extend over the wagon, causing much trouble in pulling the tent down on that side. With a small, symmetrically shaped tree the tent can be lowered rapidly into place without any trouble whatever. After

the trail ropes are all played out, the main rope is loosened and the tent allowed to settle to the position desired, and fastened there. There yet remains the job of seeing that the tent is tight to the ground on all sides. The trail boards are made to lie on the part of the tent that is on the ground, and earth is thrown on

FIG. 18—ADJUSTING LARGE HOOP TENT

any part of the edge of the tent that does not lie down well. When both tents are thus in position they are ready for the man who charges the generator.

The hoop tent.—The form most used in California is the hoop tent, which is a development from the bell tent, and is of the same general shape. The hoop was first used as a means of keeping the mouth of the bell tent open, but it was soon discarded in favor of the

trail boards. It was, however, discovered that for rather small-sized tents the hoop afforded a better means of handling than did the derrick.

The hoop tents now in use range from eight to fourteen feet in diameter. They are made in the same way as a bell tent, omitting, however, the arrangements for suspending them, and possessing, instead, a series of cloth loops for attaching the hoop, as is shown in the engraving.

The hoop is usually made of three-quarter-inch gas-pipe; half-inch pipe will do for the smaller sizes, but it is too weak for hoops above ten feet in diameter, as it bends too easily and soon becomes very crooked. To make the hoop, pipe is coupled together until the proper length is reached, according to the size desired, and then bent into shape. The union is then made by inserting into the ends a piece of iron rod a foot or less in length and just small enough to enter the pipe. Holes are now drilled through the pipe and rod, and rivets are inserted, thus making the joint fast. A coupling with right and left hand threads might be used instead of the rod and rivets.

The manipulation of a hoop tent varies according to its size. When the diameter of a tent is not much greater than the distance between the nearest branches of adjacent trees, the procedure is that illustrated in Figs. 14–16.

To move such a tent from one tree to the next, two men place themselves on opposite sides of it, grasp the hoop, and raise the side which is opposite the tree to which they intend to move it; they step sidewise, dragging the side that is on the ground closer to the

trunk. The men, still holding the hoop as they first grasped it, continue to raise the free side until it passes over the top of the tree, when it is allowed to fall to the ground between the two trees. In falling, the hoop naturally moves away from the tree from which it came, so that the cloth falls over the

FIG. 19—LIFTING TENT AFTER FUMIGATION

edge of the hoop. If this does not occur, the tent is pulled into that position in order that, when the hoop is raised, the center of the tent will be brought at once to about the center of the top of the tree.

The men now grasp the hoop again, as before, carry it toward the tree and lift up the further edge, then with one movement throw it over the tree. Often it will go clear to the ground and needs no further

attention. The cloth which extends beyond the hoops forms a sufficiently tight contact with the ground if the latter is ordinarily level.

The manipulation of the *large* hoop tents differs from that above described, from the fact that the

FIG. 20—COVERING TREE WITH LARGE HOOP TENT

proximity of the trees makes it impracticable to lay the tent on the ground. The procedure in this case is indicated by Figs. 17–20 and in the accompanying diagram, Fig. 21.

It is better to have three men handle these tents, though two can do it. When working three, two take hold in the same way as described above for the small hoop tents, and the third pulls on the side that is raised. The latter then catches the hoop with a fork at the end of a pole, and as the others lift

he assists by pushing. This is shown in Figs. 19 and 20.

When the hoop has taken about the position shown at *B*, in Fig. 21, or a little past that point, the two men holding the sides of the tent carry it to the next tree to the position *C*, and then without pausing, and while the tent is full of air and streaming out behind with the aid of momentum acquired, the upper edge

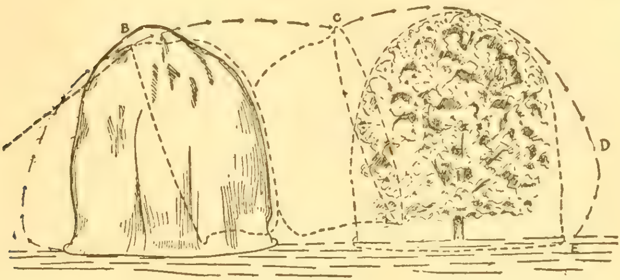

FIG. 21—DIAGRAM ILLUSTRATING METHOD OF SHIFTING LARGE HOOP TENT. (AFTER WOODWORTH)

of the hoop is forced over the top of the tree and down on the other side. Generally it is possible to throw the hoop into the position *D*, when it can readily be pulled down to the ground.

If there is any trouble in pulling the cloth over, the third man, having tossed his pole to the next tent, goes around to the near side of the tent just moved, and as the others pull on the far side, shakes the cloth of the tent away from the tree, thus relieving some of the friction. The weight of the hoop of these large tents greatly helps in the process of slipping the cloth over the tree,

the most energy being required in removing the tent. The large tents are moved quite as rapidly as are the smaller ones. It will be noticed that the cloth is turned inside out with each change in the case of the larger tents, but with the smaller ones the same side of the cloth is always next to the tree.

FIG. 22—ORCHARD WORK WITH SHEET TENTS IN THE EAST

CHAPTER VII

CONSTRUCTION AND MANAGEMENT OF SHEET TENTS

THERE are many methods used for handling sheet tents in orchards. A single pole, such as shown in Fig. 24, is very useful. The pole is known as a "lifter," and consists of an eighteen-foot yellow pine sapling, thoroughly sea-

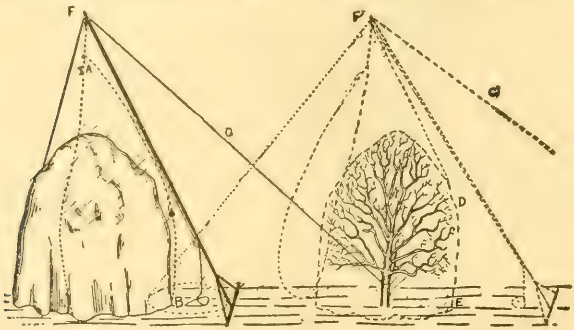

FIG. 23—MANIPULATING SHEET TENTS WITH A SINGLE POLE (AFTER WOODWORTH)

soned, such as is used on ordinary sail-boats. It should be about four inches in diameter at the base, tapering to about three inches at the top. Such a pole is strong, light, and very durable. A piece of 3 x 4 inch scantling is nailed at the base and braced, as shown in the illustration. A small block pulley, large enough to carry a five-eighths inch rope, is screwed near the top of the lifter. Forty to fifty feet

FIG. 24—METHOD OF COVERING A TREE WHEN A SINGLE POLE IS USED

of half or five-eighths inch rope will be needed in the pulley. This is called the "pulley rope." A cleat should be attached to the side of the lifter about five feet from the ground. The pulley rope is attached to this when the tent is hoisted. Another piece of rope, twenty-five to thirty feet in length, should be tied near

FIG. 25—REMOVING SHEET TENT BY MEANS OF POLE AND HELPERS

the top of the lifter above the pulley. This is called the "stay rope." The lifter is kept in place by means of the stay rope by tying it to an adjacent tree, as illustrated.

Various other appliances will be found helpful. Usually the conditions will suggest some improvement whereby the tents can be handled more easily. A hand pole, such as is shown in Fig. 25, can be used to good advantage in tenting and untenting a tree. This

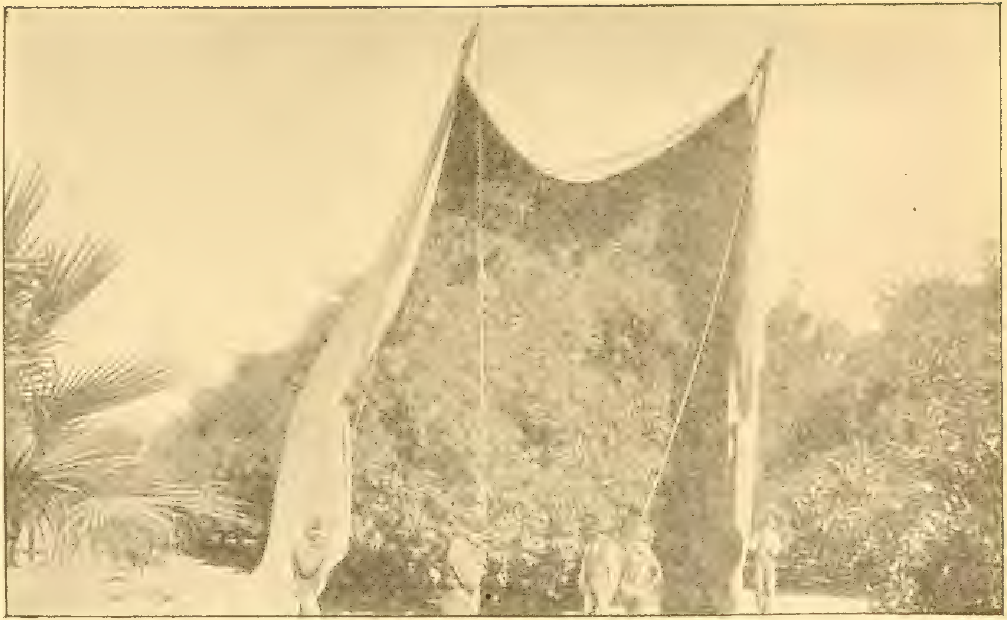

FIG. 26—COVERING LARGE ORANGE TREES WITH A SHEET TENT

is known as the "helper," by means of which the weight of the tent can be kept from the tender branches of the tree. The helper shown in the illustration gives a good idea of the construction and its method of use. In this particular case the tent is being removed from the tree which has just been fumigated.

To tent a tree where a single lifter is used, it should be set at an angle of about sixty degrees and the stay rope fastened to an adjoining tree, thus holding it in place, as shown in Fig. 23. One end of the pulley rope is then passed around the tree and tied to the tent lying on the ground on the opposite side. The operator at the lifter then draws the tent to the pulley and fastens the rope. He then steps back a few feet, and, taking the stay rope, pulls the lifter toward himself until the center of the tent is about over the top of the tree, as shown in Fig. 24. In the mean time the other assistant brings the sides of the tent around toward the lifter. The operator takes one side while the assistant holds the other, as shown in the illustration. When the lifter is at the proper angle to bring the center of the tent over the top of the tree, one side of the tent is then passed to the assistant between the lifter and the tree, while the operator loosens his pulley rope and lets the tent fall in position over the tree. The assistant unties the stay and pulley ropes and carries the lifter to the next tree, while the operator banks the tent or folds the cloth around the base of the tree. Often a few shovelfuls of earth are necessary to hold the bottom of the tent in place, if there is not a sufficient amount of canvas to fall on the ground. If the wind is blowing

FIG. 27—SHEET TENT IN POSITION OVER AN ORANGE TREE READY FOR CHEMICALS

and the tent is a little slack a few pieces of stone or chunks of wood may be required to hold it down.

When the trees are uniform in size as many rows are taken as there are tents in use. The sheet tents are then transferred from tree to tree by simply reversing them over and over again. The method varies from the foregoing only in the fact that the pulley rope is carried around the side opposite the lifter and fastened to the bottom of the tent covering the trees. The lifter is also set at a more acute angle. The canvas tents with square tops, however, can not be reversed in this manner. In such cases they are taken from the tree, lowered, and again hoisted in the usual manner. The method of untenting a tree in an Eastern orchard is shown in Fig. 25. On very large trees two lifters are usually necessary, and in this manner the weight of the tent can be kept almost entirely from the branches.

California outfit.—In addition to the descriptions of the apparatus already given from California, Figs. 26–29 will be of interest. These photographs were furnished by R. B. Cundiff, chairman of Riverside County Board of Horticultural Commissioners, and were taken for the United States Department of Agriculture for the Year-Book of 1900. It will be seen by the figures that these tents are of enormous size and are handled by two lifters, one on each side of the tree, Figs. 26 and 30. The tent is pulled into position very much in the same manner as already described. After the tree is covered, as shown in Figs. 27 and 31, the canvas is folded around the base and the gas is generated. A novel feature of the outfit used in the

FIG. 28—REMOVING SHEET TENT BY THE ASSISTANCE OF A HORSE

FIG. 29—FUMIGATING APPARATUS READY FOR TRANSPORTATION

Riverside district is, that the tents are removed by means of a horse, as shown in Fig. 28. In transporting these tents and the apparatus, a low-wheeled

FIG. 30—TENTING AN ORANGE TREE IN RIVERSIDE DISTRICT, CALIFORNIA

wagon is used on which the entire outfit is packed, as shown in Fig. 29.

When using a large tent for a very small tree, the tent is pulled up so as to have sufficient slack canvas to cover the tree. This is usually pulled over by hand. When being removed, the cloth is pulled back

FIG. 31—TENT IN POSITION, ABOUT READY FOR CHEMICALS

in the same manner and dragged along the ground to the next tree. Where there is fear of breaking the branches in removing a large tent, the weight is usually taken off by means of the lifter. The tent, by this method, slides over itself and protects the tree. It is transferred from tree to tree in accordance with the methods already described.

CHAPTER VIII

EMORY FUMIGATOR WITH MODIFICATIONS

AFTER much experience with sheet tents in Eastern orchards, and while confident the gas could be used to good advantage, it was evident to the writer the method would have to be simplified before it could be used by the average fruit grower. The main difficulty was in the calculation of the cubic contents of a tented tree and the measurement of the chemicals afterward. The folds in a tent over a tree are so extremely variable it is almost impossible to calculate the cubic contents, even approximately. As the success attained by this method depends entirely upon the exactness with which the operation is performed, it was therefore necessary to find a system less variable for deciduous trees.

First of all, a method by which the cubic contents could be kept nearly constant, and one that could be applied without the wear and tear upon the tree by the tent, resulting in the destruction of so many fruit and leaf buds, was desirable. After much thought and consideration, it seemed that both objections to the sheet tent system could be overcome by the construction of a box with a square base, varying in hight to suit conditions and having a canvas hood. It was also necessary to cheapen the cost of the equipment, if possible.

Light wooden frames were constructed and covered

with heavy rawhide building paper. The largest box was six feet square at the base and eight feet high, as shown in Fig. 34. It was put together with three-inch butt hinges, and could thus be easily opened by drawing the butts from one side. The hood is made

FIG. 32—MODEL TYPE OF EMORY FUMIGATOR WITH HOOD FULLY EXTENDED

of eight-ounce ducking, and is six feet four inches at the base, four feet square at the top, and seven feet high. It is kept in place by means of cleats around the top of the frame, as seen in Figs. 33 and 34.

FIG. 33—PRACTICAL WORK WITH THE EMORY FUMIGATOR

The hood is first placed over the top of the tree, after which the frame is drawn around and closed. After the bottom of the hood has been securely fastened to the top of the box and a little dirt has been thrown around the bottom, the frame is tipped back slightly and the chemicals are introduced. At the ex-

FIG. 34—EMORY FUMIGATOR, PAPER TYPE, COMPARED WITH SHEET TENT

piration of the proper time the hood is removed, the box opened and slipped around the next tree. Boxes under six feet in hight were constructed without hoods and the sides screwed together. These can be handled easily and can be used on small trees, where it is not practicable to use a tent.

It was slow work and troublesome to place the hood, arrange the box, and get it ready for operation each time. The system, however, was as near perfect

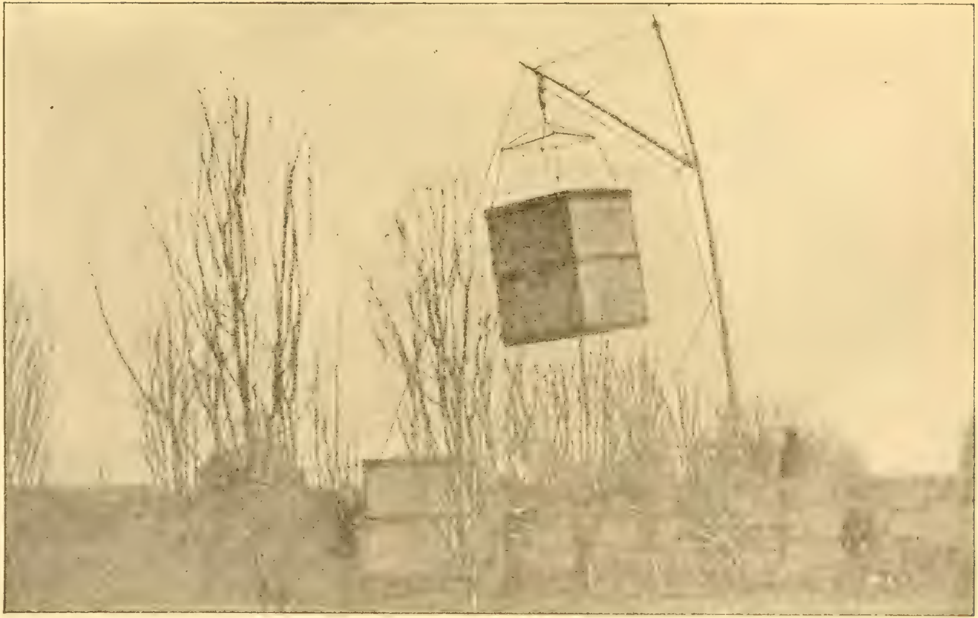

FIG. 35—APPARATUS FOR MANIPULATING THE EMORY FUMIGATOR

as we could expect it, and we began work to overcome the two serious objections. First, a box with a permanent hood, and, secondly, one that could be handled without being opened on the sides was needed. At the same time, while we found the rawhide paper perfectly satisfactory on the large box, it was quite troublesome to put on the frame smoothly. The edges were first glued and then nailed. It was also easily punctured by a broken limb unless great care was taken. This last point was not a serious objection, and little or no trouble was experienced on that account. A material, however, with more elasticity was desirable.

Taking all these points into consideration, a box of the same dimensions, covered with eight-ounce ducking, was constructed. The sides were screwed together, and the hood fastened on permanently with narrow strips screwed to the top of the frame, as shown in Fig. 32.

Having completed this box, the most serious obstacle arose. How could a box of such dimensions, with permanent hood and sides, be handled? There was only one way to do it, and that was to pick the box up and lower it over the top of the tree. The problem was solved by the ingenuity of Robert S. Emory. It was accomplished by means of a thirty-five foot mast made of spar pine and a twelve-foot gaff of the same material. It was fitted with ropes and pulleys, and rigged to the running-gear of an ordinary farm cart, as shown in Fig. 35. By means of this it could be raised and lowered over any tree under seventeen feet in hight. The system worked perfectly, and was

FIG. 36—FUMIGATING AN ORCHARD ON A MOUNTAIN SIDE

applied in a block of infested pear trees the first and second week in April, 1899.

It requires three or four men to operate an outfit of this kind ; the help, of course, depending on the number of fumigators in use. It requires one man to look after the chemicals and time, and two or three to handle the fumigators and rigging. With an equipment of ten fumigators this force, under favorable conditions, can in one day fumigate from one hundred and seventy-five to two hundred trees, varying from twelve to seventeen feet in hight. The cost of the chemicals is about four cents for the eight-foot box without the hood extended, five to six cents when the hood is half extended, and six to seven cents fully extended.

The cost of the large fumigator complete, as seen in Fig. 32, is about $12, or about two-thirds that of a twenty-five foot sheet tent sufficient for covering a tree of the same size. The rigging for handling the fumigators costs about $12. Taking it all in all, this system is simple and can be used by the average orchardist.

In giving this method for handling hydrocyanic acid gas to the public, it should be said that the author has had the practical experience of Robert S. Emory, of Maryland, without which it would not have been possible to have completed the experiments and perfected the apparatus. The mechanical details were under his entire personal supervision. As a slight recognition of his services and practical experience, this apparatus has been named the "Emory Fumigator."

The Miller type.—The Emory fumigator has been

FIG. 37—PRACTICAL APPLICATION OF THE EMORY FUMIGATOR ON ROUGH LAND

modified somewhat by H. W. Miller, of West Virginia, types of which are shown in the accompanying illustrations. It is constructed for use in orchards, where the trees are eight to ten feet high. These fumigators

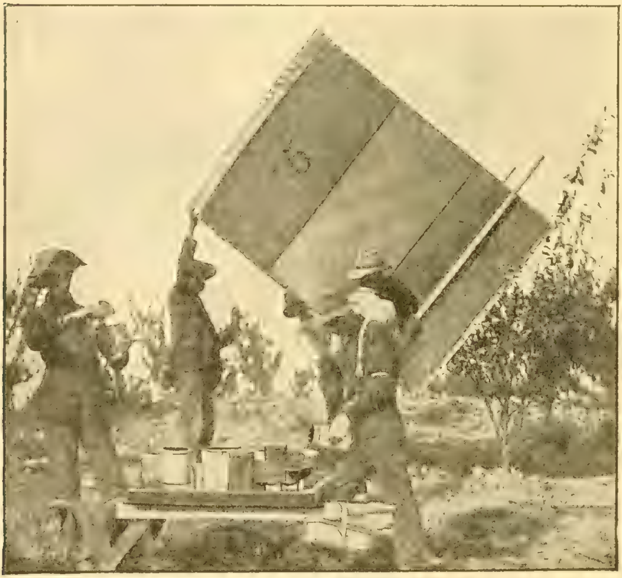

FIG. 38—PLACING FUMIGATOR OVER TREE. TRAY AND APPARATUS FOR CHEMICALS

are five feet square and seven feet high, with flat top. A light wooden frame is first made, around which three breadths of eight-ounce ducking (carefully sewed together) is wrapped and tacked along one edge with tin heads, such as are used for holding building paper in place. The top piece of cloth is also tacked around

the upper edge in a similar manner. The cloth is then thoroughly painted with boiled linseed oil and allowed to dry. Two coats are given if necessary, one being applied to the inside.

To facilitate the handling of these fumigators two

FIG. 39—FUMIGATOR NEARLY IN POSITION

strips of wood are nailed on opposite sides, as shown in Fig. 38 and others. At the top, near the center, a piece of half-inch rope two to three feet in length is tacked, with which the operator can easily tip the tent

forward, allowing the gas to escape before the apparatus is transferred from one tree to another.

With an equipment of fifteen fumigators of this type three hundred to four hundred trees can be covered in a day at a cost, including labor and chemicals,

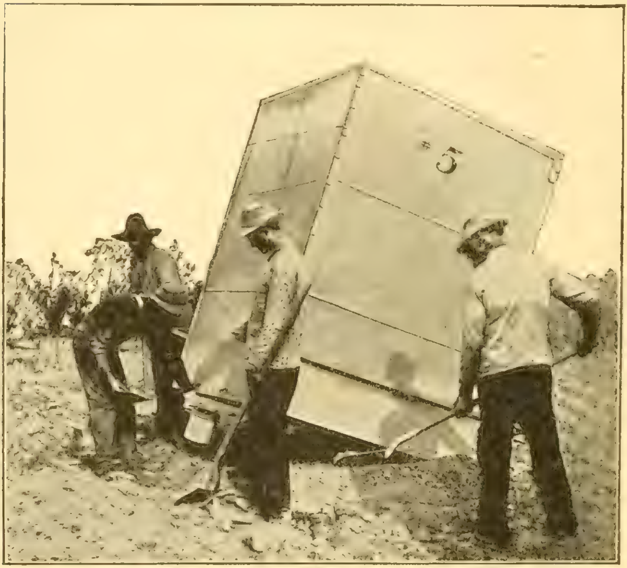

FIG. 40—PLACING THE CHEMICALS UNDER FUMIGATOR

of about six cents per tree. For an outfit of this character in mountain orchards, where the ground is rough, ten men are necessary to manipulate it to best advantage. Three men handle the boxes, as shown in Fig. 39. It also requires three individuals to shovel the earth around the base of the fumigator, as seen in Fig.

40. Two men attend to the chemicals, weighing the cyanide and measuring the acid and water, as shown in Fig. 40. In this particular case one man was employed to level the ground around the trees, so as to facilitate the handling of the fumigators. A general

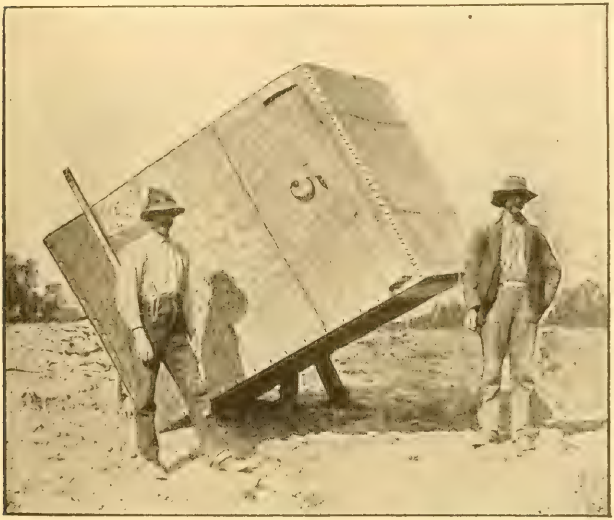

FIG. 41—AIRING THE FUMIGATOR JUST BEFORE REMOVAL

foreman and timekeeper was necessary, so that the boxes could be transferred at the proper time and without delay.

The cost of the fumigator of this type need not exceed $5, including oil, provided the work is done at home. The outfit illustrated in Figs. 36 and 37 is a home-made construction. After using fumigators of this type the canvas can be easily removed and used

for other purposes in orchards and farm work. In some cases the sheets are used to cover fruit in wagons as it is hauled to the station. The frames are put together with nails or screws, and are easily taken to pieces and stored away for future use. This type of fumigator is valuable for small trees and shrubs in orchards and on private grounds. The method of operating this type of fumigator is shown in Figs. 36 to 42, taken by the author expressly for this work.

A box fumigator.—A new style, much after the old type of the Emory fumigator, has been designed by Prof. V. H. Lowe, of the New York Experiment Station. It is intended for use with the smaller orchard trees, such as peach, pear, plum, and quince. A good idea of the general construction of this apparatus can be gotten from a study of Fig. 43. The dimensions are 10 x 6 x 6 feet. The frame consists of well-seasoned pine strips three inches wide and seven-eighths inches thick, braced on three sides by double cross-pieces of the same thickness and one and one-fourth inches wide. The base is made of four-inch strips and has but three sides, the fourth being omitted to avoid the necessity of lifting the generator from the top of the tree before putting it in place. The frame is covered with eight-ounce ducking, such as described for the Emory tents and other fumigators. The cloth was oiled with boiled linseed oil, in which lampblack was mixed to give it a dark color. To prevent trees from penetrating the top of the fumigator a stout wire netting was tacked on the inside of the upper half of the frame.

A strip of canvas one and one-half feet wide was

attached to each side of the base of the frame. The strips lap at the corners, so that when the fumigator is in place they lie on the ground and can be covered with dirt or sand-bags, thus preventing the escape of

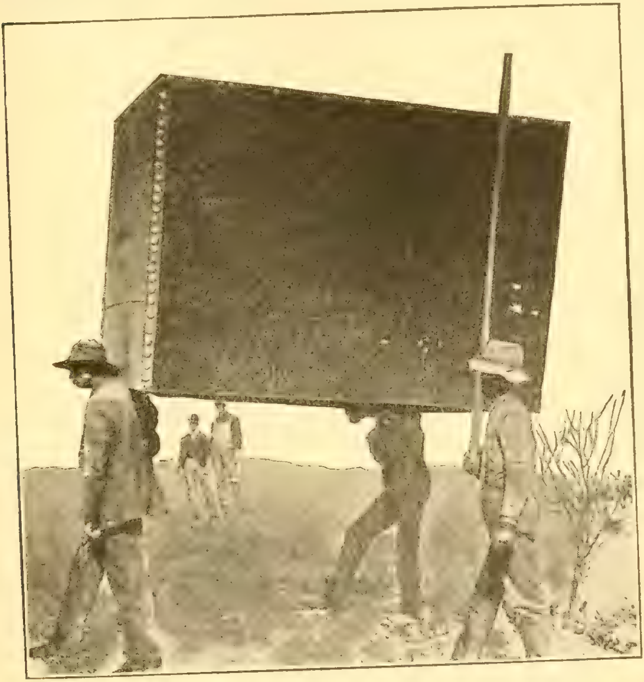

FIG. 42—TRANSFERRING THE FUMIGATOR

the gas. These strips can be hooked up and kept out of the way when the fumigator is being carried from one tree to the other. The movable side of the fumigator can be easily put in place or taken off. It is

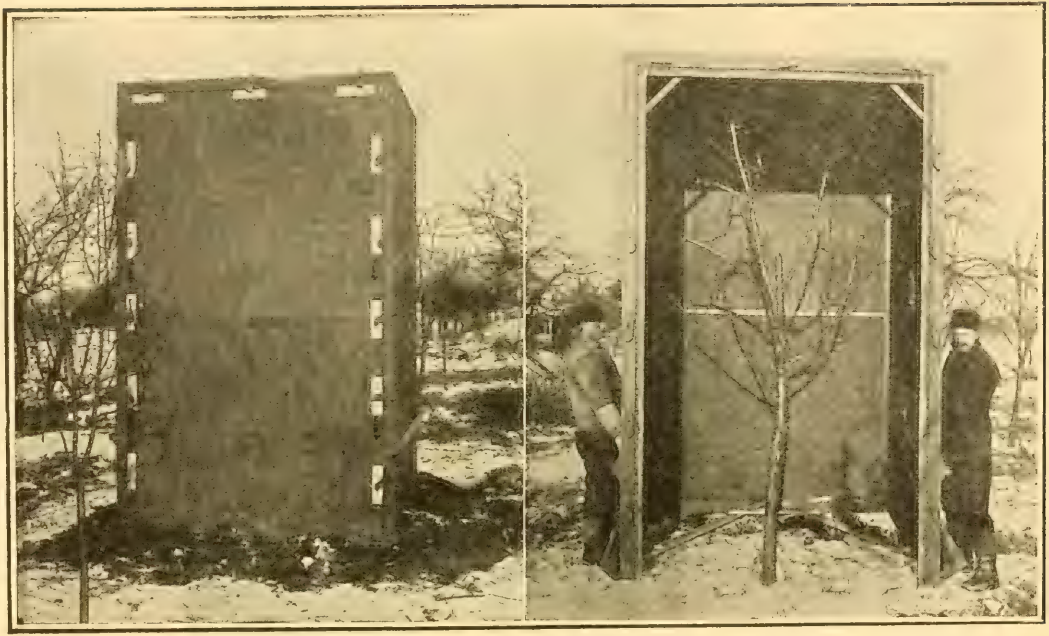

FIG. 43—FUMIGATOR DESIGNED AND USED AT THE NEW YORK EXPERIMENT STATION

provided with four handles, as shown in the illustration. There is a two-inch flange covered with a good quality of felt, against which the door rests. The surface of the frame which rests against the flange is covered with the same material. There are two flat pieces projecting on each side from the base of the frame upon which the door rests. There are thirteen buttons by which the door is fastened and kept in place, as illustrated.

The cost of a fumigator of this size varies from $13 to $18, according to the material used in its construction. This fumigator has been severely tested at the New York Experiment Station and found very satisfactory. The time required for moving it from one tree to another varies somewhat with conditions, but as a rule it can be set up in from ten to fifteen minutes. It can be operated and easily carried by two men. A fumigator 12 x 8 x 8 feet, built according to this style, would no doubt be practical, and would require about three men to handle it. The removal of one side prevents the necessity of lifting it over the tree, as is the case with the Emory type.

CHAPTER IX

ESTIMATING GAS FOR ORCHARD WORK

A*MOUNTS OF CHEMICALS*.—The foreman or superintendent should be responsible for the chemicals used for making the gas. As a rule, where the sheet tents are used, different amounts are necessary for individual trees, especially where they vary in size. The superintendent judges the size of the tree as soon as it is tented, and estimates and weighs the chemicals accordingly. It is difficult to estimate the cubic contents of a tented tree, and as a result some unsatisfactory work is done. Indeed, it is surprising that the results are as uniform as they are. In California the trees to be fumigated are usually inspected in advance, so that the superintendent can, in a general way, estimate the amount of gas necessary. A little more gas than the tree will stand without injury is usually produced. This is somewhat misleading, for the larger the tree the greater the injury. If the dose is properly proportional to the cubic content, there is a slower diffusion of the gas, in which case care must be taken when large trees are fumigated.

The usual method is to measure the tree and find the amount of chemicals necessary by reference to a table prepared for that purpose. If the tables are correctly calculated and the measurement accurately done this is perhaps the safest method. As already indi-

cated, it is difficult to measure and determine accurately the cubic content of a tented tree. To simplify the measurement and estimation of the tent the following table has been prepared by Prof. Woodworth, of California. The center column gives the various doses corresponding to the size of the trees in the columns on either side. Thus, on one side it has been calculated so as to give three parts of hydrocyanic acid gas in 1000 parts of air; on the other side, two parts in 1000 of air. For winter treatment for deciduous trees the first or 0.3 per cent. gas is suggested. This is about equivalent to the general recommendations given for the Eastern States. One-half of this amount is not far from the commonest practice in California for citrus trees. The 0.2 per cent. formula is suggested for citrus trees. It agrees with the amounts used by some of the most successful fumigators in California. Other individuals get fair results with scarcely more than half this amount.

The measurements to be taken when using this table are (1) around the tent, and (2) from the tent from ground to ground. If these two measurements are about equal, as will be found on many orange trees, the number nearest the measurement is found in the circumference column, and the corresponding dose will be seen in the center column. If these two measurements are not nearly the same, the outside columns become useful, for they show for each size how much difference must occur to make necessary a half ounce increased or decreased in dose; that is, for each differential there must be added or deducted one-half ounce of cyanide. For

instance, if the difference between the distance over and around the tree is five feet, and the differential for the circumference is three feet eleven inches, then the dose must be increased or diminished by a little more than a half ounce; but if the differential is one foot, then for each foot there must be added or subtracted one-half ounce, or two and a half ounces for the five feet.

CYANIDE NECESSARY FOR TREES OF VARIOUS SIZES IN CALIFORNIA

0.3 PER CENT. GAS				CYANIDE	0.2 PER CENT. GAS			
½ Ounce Differential		*Circumference of Tree*			*Circumference of Tree*		*½ Ounce Differential*	
Ft.	In.	Ft.	In.	Ounces	Ft.	In.	Ft.	In.
3	5	19	1	2	22	1	3	11
3		20	6	2½	23	7	3	4
2	7	21	11	3	25		2	11
2	4	23		3½	26	4	2	8
2	2	24	1	4	27	7	2	6
1	11	25	1	4½	28	9	2	4
1	10	26		5	29	10	2	2
1	9	26	10	5½	30	9	2	
1	8	27	8	6	31	8	1	10
1	7	28	5	6½	32	7	1	9
1	6	29	1	7	33	4	1	8
1	5	29	9	7½	34		1	7
1	4	30	4	8	34	8	1	6
1	3	31	6	9	36	1	1	5
1	2	32	7	10	37	5	1	4
1	1	33	8	11	38	7	1	3
1		34	8	12	39	10	1	2
	11	35	7	13	40	11	1	1
	10	36	6	14	41	11	1	1
	10	37	5	15	42	10	1	
	9	38	3	16	43	9		11
	9	39		17	44	8		11
	8	39	9	18	45	7		10
	8	40	5	19	46	5		10
	7	41	2	20	47	3		10
	7	42	8	22	48	9		9
	7	43	11	24	50	2		9
	6	45		26	51	6		8
	6	46	1	28	52	8		8
	6	47	2	30	54			7
	5	48	2	32	55	3		7

As an example, Professor Woodworth cites a tree 35 feet around and 36 feet over the top, using the 0.2 per cent. table. Running down the circumference column we find that 34 feet 8 inches (the nearest to 35 inches) requires 8 ounces, and that the differential is 1 foot 6 inches; that is, 35 feet requires a little over 8 ounces, and the difference between the two measurements around and over the tree, 1 foot, is nearly enough to require another half ounce, so that 8½ ounces would be about right. Suppose, again, the distance around a tree to be 40 feet, and that over the top only 35 feet; using the same table, we find opposite 39 feet 10 inches (the nearest to 40 feet) the dose 12 ounces. But the distance over the top is 5 feet less, and a less amount of cyanide will be necessary. We therefore use the differential (1 foot 2 inches) and deduct one-half ounce for each 1 foot 2 inches difference, or about 2 ounces altogether. This leaves 10 ounces as the correct dose for this tree. These measurements are not supposed to be taken with every tree, but in cases of doubt, and occasionally to correct one's judgment; and in the case of those beginning to fumigate, whose judgment is not yet developed.

The three tables following are taken from an excellent article on fumigation in the *Rural Californian*. Effectiveness demands accurate judgment as to the quantities of the chemicals to be used. This must necessarily vary according to the cubic space to be filled with gas, or, in other words, according to the size of the tree. The tables here given, based on the hight and width of tree, will be found quite practicable, but in order to eliminate as far as possible errors of

judgment regarding the dimensions of the trees to be fumigated, a stick marked off in feet will be of assistance.

QUANTITY OF CHEMICALS TO DESTROY BLACK SCALE ON CITRUS TREES

HIGHT	*Diameter*	*Water*	*Sulphuric Acid*	*Cyanide*
Feet	Feet	Ounces	Ounces	Ounces
6	4	2	1½	½
8	6	5	1¼	1¼
10	8	7	2	2
12	10	12	3	4½
12	14	18	4½	4½
14	14	20	5	5
16	16	24	5½	5½
18	16	24	6	6
20	16	26	6½	6½
22	18	30	7¼	7¼
24	20	32	8	8
26	20	33	8⅓	8¼
30	20	35	8½	8½

The proportions of chemicals used for citrus trees affected with red, brown, or purple scale are given in the following table. The same quantity may be used for deciduous trees infested with San José or black scale.

CHEMICALS FOR RED, BROWN, AND PURPLE SCALE

HIGHT	*Diameter*	*Water*	*Sulphuric Acid*	*Cyanide*
Feet	Feet	Ounces	Ounces	Ounces
6	4	3	¾	¾
8	6	7½	1⅞	1⅞
10	8	9½	3	3
12	10	18	4½	4½
12	14	27	6¾	6¾
14	14	30	7½	7½
16	16	36	8¼	8¼
18	16	36	9	9
20	16	39	9¾	9¾
22	18	45	10⅞	10⅞
24	20	48	12	12
26	20	49½	12⅜	12⅜
30	20	51½	12¾	12¾

On low, damp grounds where fogs are frequent, and especially for apple and pear trees, infested with either the San José scale or codlin moth, or old seedling orange trees infested with red, brown, or purple scale, the following table should be used:

CHEMICALS FOR ORCHARDS ON DAMP GROUNDS OR WHERE FREQUENT FOGS OCCUR

HIGHT	*Diameter*	*Water*	*Sulphuric Acid*	*Cyanide*
Feet	Feet	Ounces	Ounces	Ounces
6	4	4	1	1
8	6	10	2½	2¼
10	8	14	4	4
12	10	24	6	6
12	14	36	9	9
14	14	40	10	10
16	16	48	11	11
18	16	48	12	12
20	16	52	13	13
22	18	60	14½	14½
24	20	64	16	16
26	20	66	16½	16½
30	20	70	17	17

In the tables given above the diameter is taken through the foliage. The water and acid are estimated in fluid ounces.

In Eastern orchards the amount of cyanide is somewhat greater than that used in California. Experience has shown that 0.20 gramme of cyanide per cubic foot of space enclosed gives most satisfactory results upon scale-infested deciduous trees in the East.

In the preparation of the following table calculations are based on the hight and diameter of the tented tree. First, the cubic contents of a cylinder was calculated, the hight and diameter of which was the hight and diameter of the tree, then the contents of a sphere whose diameter was the hight of the tree was

estimated. By taking half the difference and adding it to the contents of the cylinder the estimation was found approximately correct.

CHEMICALS ESTIMATED FOR EASTERN ORCHARDS

HIGHT OF TREE	*Diameter*	*Cyanide*	*Acid*	*Water*
Feet	Feet	Grammes	Ounces	Ounces
4	3	6.17	0.32	0.48
5	4	12.82	0.67	1.00
6	4	18.85	1.00	1.50
7	4	26.75	1.41	2.11
		Ounces		
7	5	1.11	1.66	2.49
8	4	1.30	1.95	2.92
8	5	1.50	2.25	3.39
9	5	1.96	2.94	4.41
9	6	2.24	3.36	5.00
10	7	3.20	4.80	7.20
10	8	3.62	5.43	8.14
11	7	3.95	5.92	8.88
11	8	4.40	6.60	9.90
12	9	5.88	8.82	13.23
12	10	6.51	9.76	14.64
13	9	6.93	10.39	15.58
13	10	7.65	11.47	17.20
14	11	9.76	14.64	21.96
14	12	10.65	15.97	23.45
15	11	13.28	19.42	29.88
15	12	14.24	21.36	32.04
16	14	16.34	24.51	36.76
16	15	17.53	26.27	39.43
17	14	18.39	27.57	41.35
17	15	19.36	29.40	44.23
18	15	22.06	33.09	49.63
19	16	26.10	39.15	58.72
20	16	29.00	43.50	65.25

A careful study of the tables made by various individuals for orchard work is interesting. The present practice in California does not vary much in amount of cyanide used per cubic foot from that originally estimated by Coquillett and Morse. The results as summed up by Woodworth are given in the following table.

COMPARATIVE VALUE OF CYANIDE PER CUBIC FOOT FOR ORCHARD WORK

DATE	*Name*	*Capacity per Ounce of Cyanide*
1887	F. W. Morse	145 cubic feet
1888	D. W. Coquillett	95 " "
1889	D. W. Coquillett	165 " "
1891	Alexander Craw	352 " "
1894	T. B. Johnson	2[illegible] "
1896	C. W. Woodworth	3[illegible]
1898	W. G. Johnson	80 " "

CHAPTER X

DAYLIGHT FUMIGATION AND COST OF APPLICATION

In California experience has shown that the citrus orchards can not be successfully fumigated during the day. On the other hand, in the East, in deciduous orchards, daylight fumigation has been found most practicable. As a rule, Eastern orchards are fumigated during the fall, after growth is stopped and after the function of the foliage has been performed. In such instances it matters little whether or not the foliage is injured by the gas. In Fig. 44 will be seen a Japanese plum tree, one of a block of 5,000, fumigated in October with the 0.20 gramme formula. While these trees were fumigated in daylight, the foliage in this particular instance was practically uninjured. In some cases where the fumigators were left over the trees longer than thirty minutes, the foliage was somewhat seered, but no injury resulted to the trees. By referring to Chapter III. it will be seen that the physiological effect of this gas varies with certain kinds of trees, and is influenced by weather conditions and time of day.

In the Eastern orchards the gas is best applied during the daytime late in the fall or early spring, as will best suit conditions and circumstances. In Fig.

24 the apparatus was used in the plum orchard during the month of March. The buds had just begun to swell, but no injury was noted, while the scale was destroyed.

FIG. 44—JAPANESE PLUM TREE IN FULL FOLIAGE FUMIGATED IN OCTOBER

In the fumigation of nursery stock, especially in the house, it makes little or no difference at what time of the day the trees are fumigated.

Expert Opinion.—There has been considerable dis-

cussion regarding daylight fumigation in California. The following interesting letter from R. P. Cundiff, an expert on this subject and Chairman of the Riverside County Board of Horticultural Commissioners, is of timely interest: "What I say upon this subject is mainly from a local standpoint. While I seriously doubt the practicability of daylight fumigation in any locality of southern California, I am not prepared to maintain that in some localities, during certain climatic conditions, and for some varieties of scale, it might not be done with reasonable safety. However, I know of no practical fumigator who has ever advocated it. I am under the impression that those who are giving such learned opinions on this subject are possessed of more of a theoretical than practical knowledge of fumigation by hydrocyanic acid gas.

"In Riverside County we have found it necessary to fumigate but little for black scale, for it has never assumed the proportions of a serious pest, as in some of the coast counties. Our fumigation has been almost entirely for red scale. It is a well-known fact among fumigators that it requires almost double the quantity of cyanide to kill red scale that it does for black or brown scale. This must be taken into account when we come to discuss the proposition of daylight fumigation. Another consideration is the difference in temperature. Riverside, being an interior county, is subjected to several degrees more heat than localities near the coast. Another point that should be considered is the season of the year when the work is performed. Fumigation for black scale, to be in any degree effective, must be done during the fall and winter months.

Especially is this true of Los Angeles, Orange, and San Diego counties, where ordinarily an orchard is fumigated but once a year. In any of these counties from October until March is considered the best time. During this period the scale is young and will yield quite readily to treatment by fumigation.

"As fumigation for red scale seems to be equally effective at all times of the year, in order to incur the least damage to the grower, in the way of knocking off fruit, etc., also to avoid rainy weather and north winds, we have made a practice in Riverside County of doing the greater part of the fumigation between the months of May and December. This period embraces our warmest weather. In this connection I wish to refer to a matter that has evidently escaped the attention of the advocates of daylight fumigation. During our summer months we have periods, sometimes extending over many days, when the mercury will range in the nineties. With a temperature of from 90 to 95 degrees we are quite sure that by enclosing a tree under an air-tight tent for the time required for fumigation, which is from 40 to 45 minutes, the temperature under the tent would be increased from 25 to 30 degrees. Add to this the increased heat caused by generating the chemicals, which would be perhaps 10 degrees more, and the resulting temperature would very likely do harm. It is well known that a citrus tree will not stand a temperature of 135 degrees for any length of time without serious results. We know from actual observation that the action of sunlight upon hydrocyanic acid gas has a scalding or burning effect upon foliage. Practically all of the damage ever done

in Riverside County from fumigation with cyanide has been caused by an occasional mistake of the foreman of fumigation in either beginning his work too early in the evening or continuing it too late in the morning. This has, however, seldom occurred, as few fumigators who understand their business will risk their reputations by taking such chances. I recall to mind a suit brought against the county some years ago for alleged damages by one of our growers. This, I un-understand, was a case of daylight fumigation.

"I quite agree with the advocates of daylight fumigation that there would be some advantages gained by doing the work in the daytime instead of night. There would be a small saving in chemicals, but not nearly so much as claimed by some. It would be also easier to locate trees and move the apparatus from place to place. On the other hand, there are some advantages in doing the work at night. The handling of a fumigating outfit, especially where large tents are required, is very laborious. Men could do more work with less fatigue on account of the cooler temperature. This would be especially true in Riverside County, where the greater part of the fumigation is done during the warm months. I am under the impression that it would be difficult to get men to work during the very warm weather in the daytime, as the reflection of the sunlight on the tents would increase the heat to such an extent that they would prefer other work at less wages. As was intimated at the beginning, it is probable that in some of the coast counties, in fumigating for black scale, where the amount of cyanide is much less than for red scale,

fumigating could be done on cool, cloudy days with comparative safety. But in Riverside County, where the fumigation is almost entirely for red scale, where a much greater amount of cyanide is required, and where it is necessary to do the work during the warm weather, it would certainly be a very unsafe thing to

FIG. 45—CHARGING A CALIFORNIA HOOP TENT

do. And the orchardist who attempts it will probably be reminded of this fact by having his trees damaged."

The cost of orchard fumigation depends upon the location of the orchard, the kind and size of the tree, and, to a certain extent, upon the prevailing weather conditions under which the work is done. The actual cost of fumigation is not necessarily very great after the outfit is once secured. With a small number of Emory fumigators, or sheet tents, most fruit growers can apply

the gas method without difficulty if the rules given herewith are carefully followed.

Large outfits are so expensive it is desirable in many cases for the state, county, or local society to own the tents and other equipment. In California especially, where it is necessary to operate at night, these outfits are practically controlled by county and local organizations. The number of persons necessary to operate a system of fumigators depends somewhat on the size of the trees and the number and kind of tents. One or two men introduce the chemicals, others look after the vessels, measure the acid and water, while others manipulate the tents. As soon as the tent is in place, the fumigator enters it, introduces the chemicals, withdraws quickly, closes the tent, and proceeds to the next tree. In many cases the assistant raises the edge of the tent, while the fumigator enters and drops it as soon as he comes out. The wagon containing the chemicals is then drawn to the next tree. The generator beneath the tree just fumigated is removed, and the contents poured on the ground near the trunk of the tree. The acid and water are measured, carried to the next tent, and introduced, as shown in Fig. 45. Various appliances are used for carrying and handling the chemicals in an orchard in the east. A wheelbarrow or small hand-cart has been found very useful, as shown in Fig. 22. In other cases a small, table-like tray is used to carry the apparatus, as seen in Fig. 38.

The location of an orchard and its freedom from dampness and fog must be considered. The ground, trees, and the leaves should be dry when fumigated.

If perceptibly damp the gas is more liable to burn the foliage. After irrigation, where it is practical, the ground should be allowed to become quite dry before the fumigation operations begin. When trees are wet with dew or a slight rain, care should be taken to see that they are fairly dry before being tented. In some

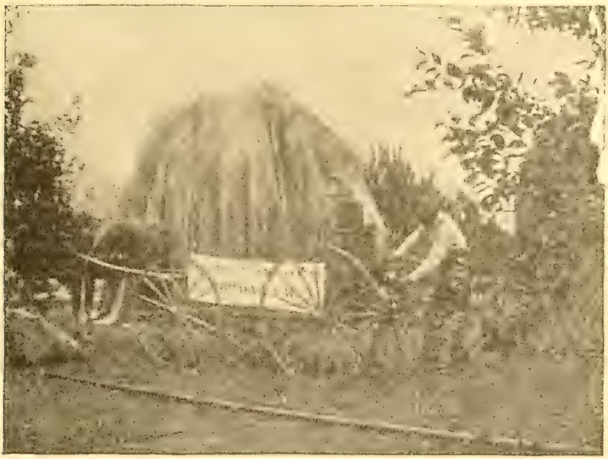

FIG. 46—WAGON FOR CARRYING CHEMICALS IN ORCHARD

instances fumigation in Eastern orchards can not be commenced before nine or ten o'clock in the morning or until the trees are dry.

Care of tents.—When a large fumigating outfit is in operation each tent should be thoroughly inspected daily. In most cases this can be done to best advantage when the tent is over the tree. The inspector should go under the tent and carefully examine it. If there are

any holes in it they can be easily detected. The places should be marked and patched at once. Sometimes a patch is glued on, but it is preferable, in most cases, to sew them on in the usual manner. For temporary purposes a small stone, nut, or even dirt, tied in the rupture will answer until it can be patched.

CHAPTER XI

EQUIPMENT FOR FUMIGATING NURSERY STOCK

THE enclosure necessary for fumigating purposes in nurseries varies considerably. In some cases boxes will accommodate the grower, but the building is usually constructed in accordance with the number of trees grown or handled. Some nurserymen have found it necessary to construct a house large enough to hold 12,000 to 15,000 first-class trees at one time. Some firms handling a million or more trees annually have rooms large enough to admit a wagon-load of trees at one time, examples of which are given in Figs. 52 and 64.

A good tent, such as is seen in Fig. 12, can be used in cases of emergency, but it is not advisable to depend upon a tent altogether. Many nurserymen have found a small box tent, similar to the one shown in Fig. 32, very useful. Still others have used a sheet tent over a wagon-load of trees to good advantage. There are some objections to a tent or box covered with canvas; in the first place, by constant use it is liable to be torn, and, secondly (and most important), the cubic capacity of space enclosed under a sheet tent will vary with the amount of stock fumigated. Herein lies the greatest source of error, inasmuch as the chemicals must be weighed every time for each individual lot of trees treated. Where the box or Emory

fumigator is employed, however, this difficulty is overcome, as the cubic content is constant and the amount of chemicals used does not vary. The danger of error is eliminated when a box or house is used. It matters

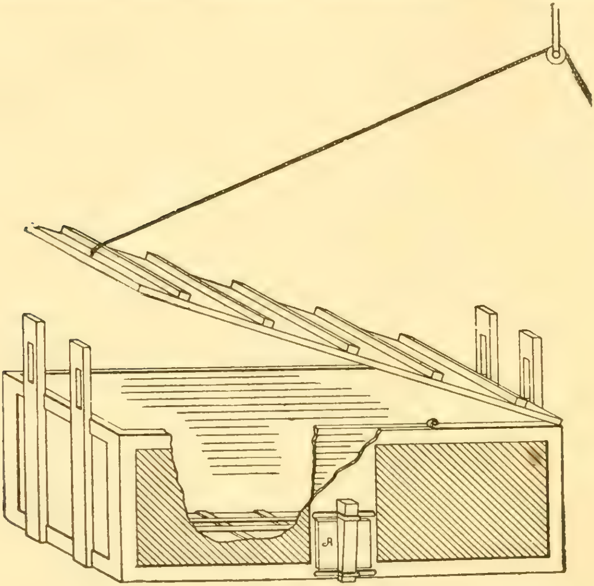

FIG. 47—BOX USED BY SOME NURSERYMEN IN THE SOUTH (AFTER SHERMAN)

not whether one or several thousand trees are placed in the enclosure, the amount of gas generated must remain constant.

Small boxes.—Many nurserymen find small boxes very useful. Fig. 47 is a box used in North Carolina. The details for construction are given by Prof. Frank-

lin Sherman, State Entomologist of North Carolina. Build box of plain matched three-quarter inch ceiling, making walls, top, and bottom double, with two thicknesses of rosin-sized or tarred paper between. Reinforce the corners with $1\frac{1}{4}$ x 3 inch stuff, and stiffen the corners with 2 x 3 inch battens.

Make the uprights of 2 x 6 inch stuff, and the two keying beams of 2 x 8 inch stuff, ceiling to be in con-

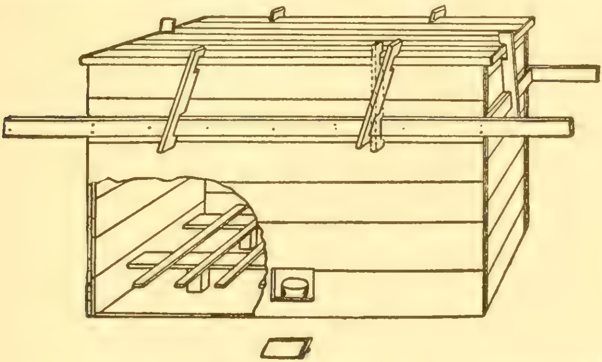

FIG. 48—TYPE OF BOX USED BY SOME CANADIAN NURSERYMEN (AFTER LOCHHEAD)

tinuous pieces, and all joints to be wiped with white lead and driven up close. Give the box two good coats of lead and oil paint, both inside and out, and repeat each year. The size of the box is ten feet long, forty inches high, thirty-six inches wide. Cover the upper edge of the box with heavy felt, glued down tight, so as to make a tight cushion-joint when top is down. Glue a two-inch wide strip of felt around the small opening near the bottom of the box. When cover is put on, the 2 x 8 inch timbers, eleven feet long, are

slipped through the mortices in the uprights, and are keyed down to force the top down tight. Nine inches from the bottom of the box put in a false slat bottom, made in sections, so it can be removed to clean out dirt from bottom of box. The chemicals are placed in a little shallow dish and put into the box through the little door, *A*, which has a shutter keyed up tight to side of box.

Another handy box, devised by a Canadian nurseryman, is made of double matched sheathing with

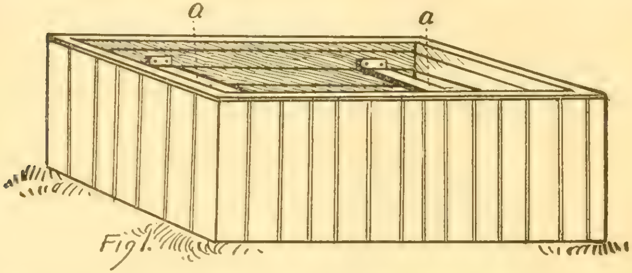

FIG. 49—THE OPEN BOX USED IN SOME MARYLAND NURSERIES (ORIGINAL)

tarred paper between. The top is held tightly against the felt padding by driving the wooden hooks from an upright into a slanting position. The hooks are made of hard wood pieces 1 x 3 inches, cut so as to hook over the edge of the lid and under the long side strip. The rack in the bottom of the box keeps the trees away from the chemicals and insures a thorough penetration of the gas. This box is shown in Fig. 48.

A plain box, 6 x 3 x 2½ feet is very satisfactory for small orders. It should be made of two thicknesses of common flooring. The construction is

shown in Figs. 49 and 50. It is a simple, plain, open box, and when filled with young trees, kept in place by a couple of slats, *a*, it is turned bottom upward on the ground and a little loose earth is stamped about the edges. The chemicals can be easily introduced by tilting the box slightly, as shown in Fig. 50. It is less troublesome than boxes having lids, and can be used to very good advantage in most cases where small numbers of trees are grown.

A fumigatorium is a house or room constructed or

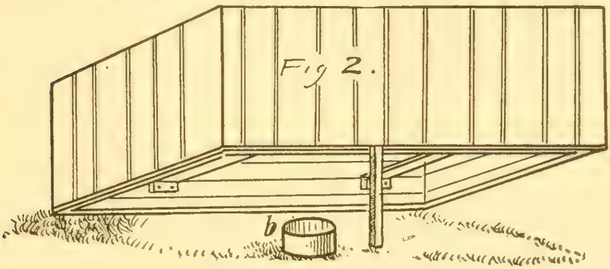

FIG. 50—OPEN BOX REVERSED READY FOR CHEMICALS (ORIGINAL)

adapted for the fumigation of nursery stock or other material with hydrocyanic acid or other gases. It is not necessary in all instances to construct a separate building for this purpose. In most cases where a nursery has been established some years a shed or one corner of a building, packing-house, or other enclosure, can be adapted so as to make a satisfactory room or house for fumigating purposes. Cover the frame inside with cheap boards; then put on three-ply cyclone or rawhide building paper, and finally the flooring. In every case have a good smooth surface on which to

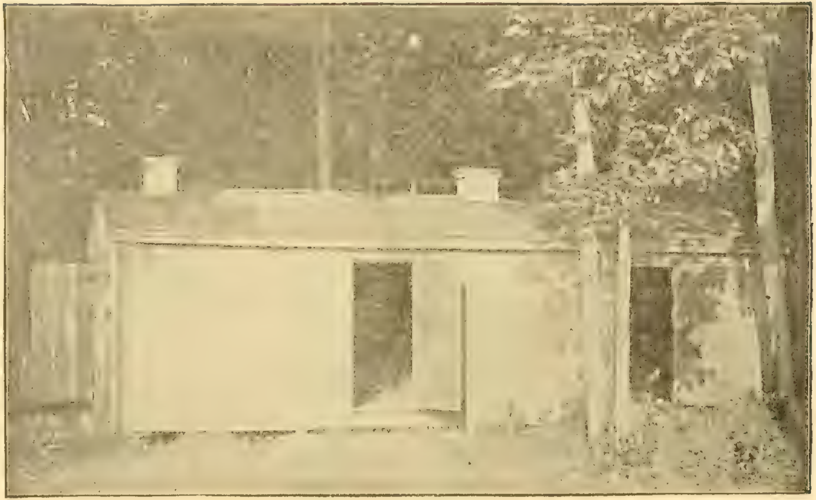

FIG. 51—LARGE AND CONVENIENT FUMIGATORIUM

secure the paper. The flooring can be joined very easily and will be tight. The ceiling and floor should be constructed in the same manner. In some cases a good solid clay floor will answer. Care should be taken to see that the house is absolutely tight at the

FIG. 52—ROOM WHERE TREES ARE FUMIGATED BY THE WAGON-LOAD

ground surface A ceiling six to seven feet in hight is most desirable and economical.

One of the largest houses in the country in which nursery stock is fumigated is shown in Fig. 51. It is 32 x 16 x 8 feet with a roof-pitch of two feet, and is divided into two large rooms about 15 x 14 x 7 feet and two smaller rooms 4 x 5 x 7 feet. The flues leading out at the top of the roof are so arranged they will

ventilate either room by removing a slide. In addition to these roof-flues there are also two small doors, 3 x 2½ feet, one for each large room, on the opposite side of the building, which, when opened, insures quick ventilation.

In the construction of this house, first a good

FIG. 53—DOUBLE ROOMS BUILT IN END OF PACKING-SHED

strong frame was built and covered outside with one and one-quarter inch twelve-inch Virginia pine boards, ¼ x 4 inch battens. The interior, including the floor, was lined with two-ply cyclone paper, over which four-inch flooring was laid. The roof was covered with heavy roofing paper, tarred and graveled. The doors are 6½ x 3½ feet, made double, refrigerating

style, and hung with three heavy strap-iron hinges. There should be a good strong bolt at top and bottom, and a lock in the middle of the door.

Another form, and very convenient house for firms handling a million or more trees, is shown in Fig. 52. It is built in one end of the packing-shed, and is 16 x

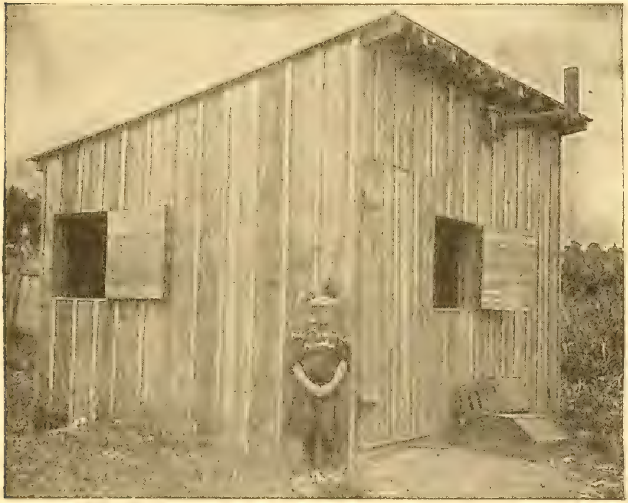

FIG. 54—SINGLE ROOM USED IN WINTER FOR GRAFTING

13 x 9½ feet. There is another room the same size on the opposite side of the building. These houses were constructed so as to admit a wagon-load of trees at one time. While a load is being fumigated in one side, the other is being removed and everything is in readiness for another charge. These rooms are really too large, and it requires a great deal of cyanide to fumi-

FIG. 55—NEATLY CONSTRUCTED SINGLE ROOM WITH CORRUGATED IRON ROOF

gate space not occupied by trees. For example, the space occupied by the wagon must be considered. The construction of this house is the same as the preceding, except that the roof is of corrugated iron and a clay floor.

Another type of house is shown in Fig. 53. Here

FIG. 56—VERY HANDY AND CHEAP HOUSE FOR SMALL NURSERY

the two rooms are built in the end of the large packing-shed. There are two doors, same size as those opening outside, leading into the packing-shed. The rooms are filled with trees, and when fumigated and ventilated, by means of a large flue leading out the top of the roof, they are passed into the packing-shed.

This is one of the handiest and best-constructed houses in Maryland.

A single room, suitable for a quarter to a half a million trees, is shown at Fig. 54. This house is constructed with sliding windows in addition to the small doors. The flue is so arranged that it can be used as a chimney, if necessary, in winter. In fact, this is called the "handy house." In cold weather it is used for grafting. The room is 13 x 11 x 8 feet.

Another single room of smaller size is shown in

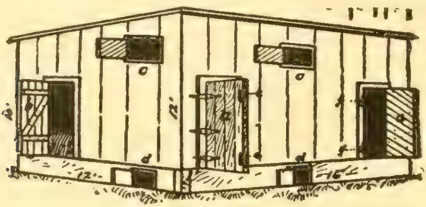

FIG. 57—OUTLINE OF MODEL FUMIGATING HOUSE. (ORIGINAL)

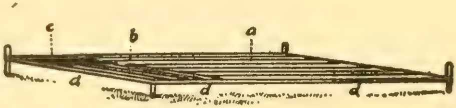

FIG. 58—PLAN OF SLAT FLOOR. (ORIGINAL)

Fig. 55. It is a very handy and neatly constructed house. It is 12 x 14 x 7 feet. It is sided up with first-class tongue and grooved flooring, instead of ordinary boards, and has a corrugated iron roof. There is a small door in the opposite end, with a sliding window. This house accommodates a firm handling a quarter of a million trees annually.

A very handy and economical house is shown in

Fig. 56. It consists of one large room, 10 x 8 x 7 feet and two smaller rooms, each 4 x 4 x 7 feet. Only one of the smaller rooms is lined. The other one is used as a storeroom, in which all chemicals and other materials are kept.

One of the most convenient houses used has a ground plan of 12 x 16 feet. It is divided into three sections, as

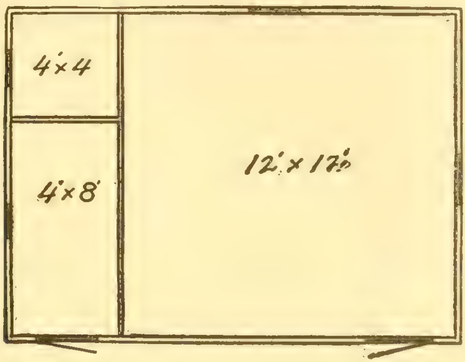

FIG. 59—GENERAL PLAN OF FLOOR. (ORIGINAL)

follows: one large room 12 x 12, and a small room 4 x 8, with a storeroom 4 x 4 feet. The floor plan and general outline of this building are shown in Figs. 57, 58, and 59. It has a double floor with paper between, and a space of one and one-half feet, as shown in the diagram, *d d*, above which there is a slat floor, on a level with the bottom of the door, as shown at *a* and *b*. In the storeroom, *c*, the floor is solid. In the construction of this building the slats should be made in sections, so they can be removed. It will be found necessary to clean the lower part of the house from

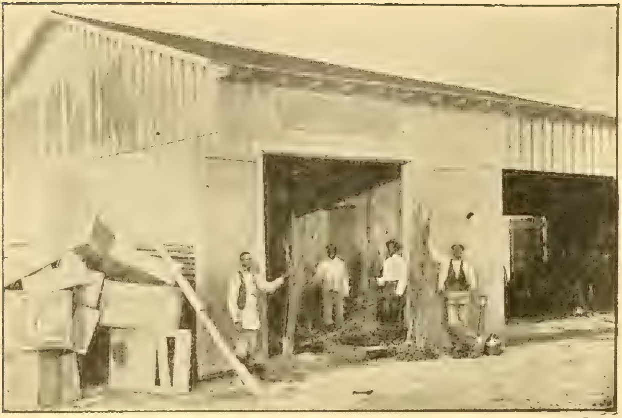

FIG. 60—WHERE TREES ARE FUMIGATED BY THE MILLION

FIG. 61—A WELL-BUILT SINGLE-ROOM HOUSE FOR SMALL NURSERY

time to time, as more or less dirt will rattle through the slats upon the floor. The slats are used so that the gas can be generated underneath the nursery stock, thereby obtaining a more general diffusion.

The jar containing the chemicals can be placed under the slats through the small doors at the base,

FIG. 62—A COMPLETE FUMIGATING HOUSE IN UTAH

d d, and very often it is advisable in a large room to have two doors of this character, so that the chemicals can be divided and the gas generated on opposite sides. Good results are obtained where this plan is followed. The small doors used for ventilation purposes, *c c*, can vary in size to meet the conditions. The door entering the storeroom need not be double, and 3 x 6 feet is a convenient size. A good solid

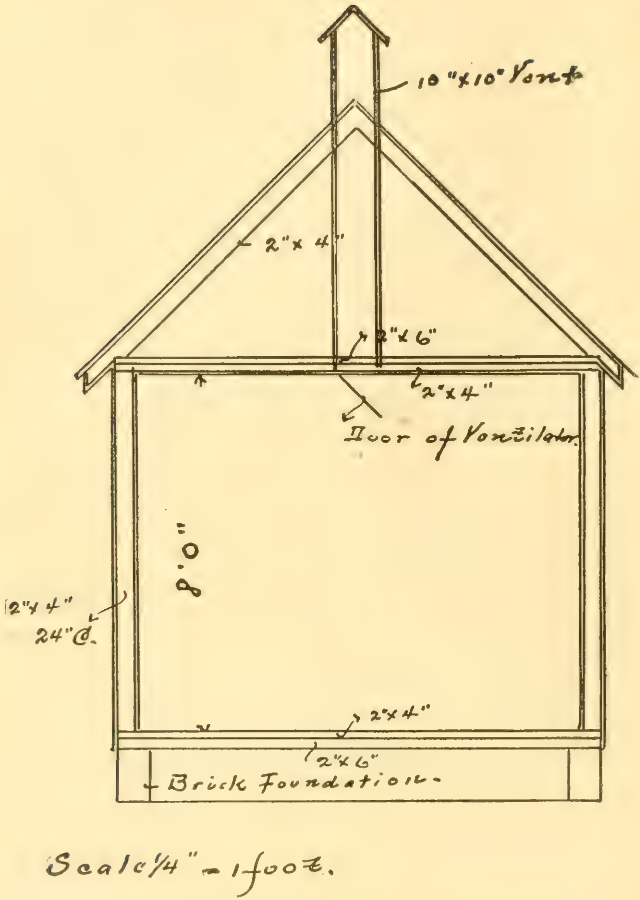

FIG. 63—SECTIONAL VIEW OF A MODEL UTAH HOUSE
(AFTER MOORE)

dirt floor will answer, provided the room is made perfectly tight at the bottom.

Two other model houses are shown in Figs. 60 and 61. The former is for a large nursery, while the latter is used for a smaller concern, handling half a million

FIG. 64—DOUBLE HOUSE IN CANADA FOR FUMIGATING TREES ON A WAGON

trees or less. The latter is used for a storehouse when not in use for fumigation.

One of the newest fumigating houses in the northwest is shown in Fig. 62. It is 10 x 14 feet. The details of construction are about the same as those already given. The ventilator and method of operating it is shown in Fig. 63. This house, complete, cost about $70.

Of the many fumigating houses in use in Canada

those shown in Figs. 64 and 65 will serve as examples. Figure 64 is a view of a double house. It has two separate compartments. While a load of trees is being fumigated in one compartment, ventilation is taking place in the other. It has two thicknesses of lumber, one matched, tongue and grooved, the other either the

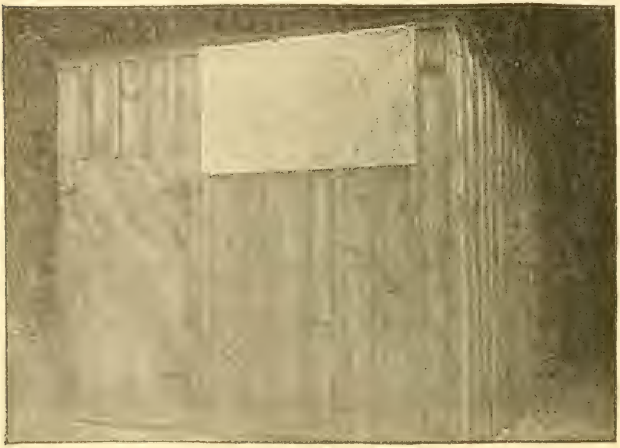

FIG. 65—CANADIAN FUMIGATING HOUSE AT THE ONTARIO AGRICULTURAL COLLEGE

same or cover-siding well-matched, and two thicknesses of paper between. The doors are the same and padded all around.

Figure 65 shows the fumigation house at the Agricultural College at Guelph, Canada. It is substantially built, dressed lumber being used in its construction. Its size is 10 x 8 x 7½ feet. It contains 600 cubic feet. The frame, of 2 x 4 inch scantling, has two

thicknesses of lumber, both matched, tongue and grooved, and firmly nailed on the outside, with a thickness of tarred paper between. Besides, the seams on the outside are covered with strips. The doors are of the refrigerator style, and the casements are padded with soft felting. Large wooden buttons are placed on the outside, around the edge of the door, to force it closely into the padded casement. The roof has a thickness of matched boards, then a thickness of tarred paper, then shingles. The cost of the complete building was a trifle over $20.

CHAPTER XII

CONSTRUCTION OF VENTILATORS AND FLOORS

One of the Canadian houses has a unique ventilator. Just before the gas is generated the hinged trap is pulled up tightly against the felt, and the rope fastened to a cleat on the side of the house, as shown in Fig. 66. Before the

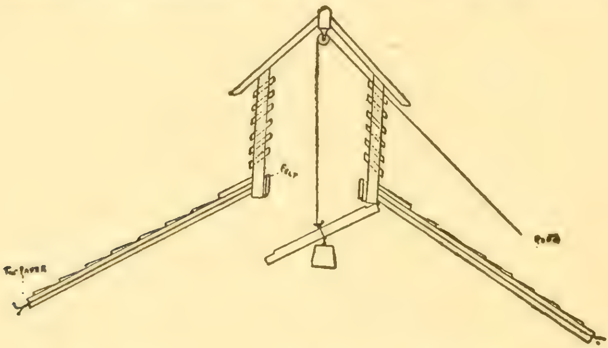

FIG. 66—METHOD OF VENTILATING A FUMIGATING HOUSE (AFTER LOCHHEAD)

door is opened the rope is loosened, and the weight brings down the trap and allows the gas to escape. A ventilator of this kind having the trap opening into the inside is protected from the weather, and is not subject to the troublesome warping of exposed cap ventilators.

An Ohio arrangement.—In his practical work in

Ohio, Prof. F. M. Webster has found slats raised eight inches or a foot from the ground preferable to the ground floor. Where it is intended to drive wagons into the house the ground floor will answer all purposes. With a slat floor the gas is generated beneath, and spreads almost instantly throughout the space between the ground and the slats, passes up-

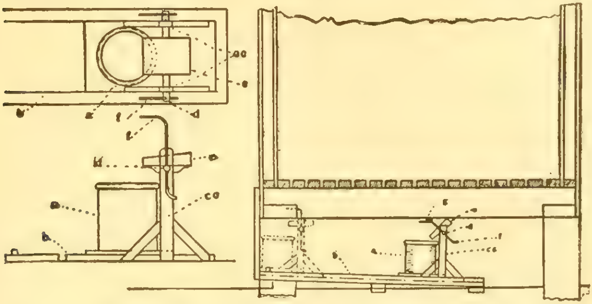

FIG. 67—DIAGRAM OF GENERATOR AND SECTIONAL VIEW OF FUMIGATORIUM. (AFTER WEBSTER)

ward through the trees, and promptly reaches every part of the apartment.

The generator, shown in Fig. 67, consists of an earthen jar of the requisite capacity, *a*, fixed to the end of a plank, *b*, and just in front and between two posts, *cc*, through which passes a roller, *d*, and to this last is fixed a pan, *e*, with back and sides but no front, one end of the roller projecting beyond the post with a small iron bar or heavy wire, *f*, passing through it, and being fixed and bent at either end, the whole having much the appearance of a windlass with pan, *e*, added. The sulphuric acid and water are

placed in the jar, and the potassium cyanide in pan above, and the plank pushed down a slight incline, as seen in the figure, over which a cleat, *g*, is fastened, which catches the wire or rod, *f*, and thus dumps the pan, *e*, throwing the contents into the jar, *a*, thereby completing the mixture and generating the gas; and, as a drop-door closes as soon as the plank is

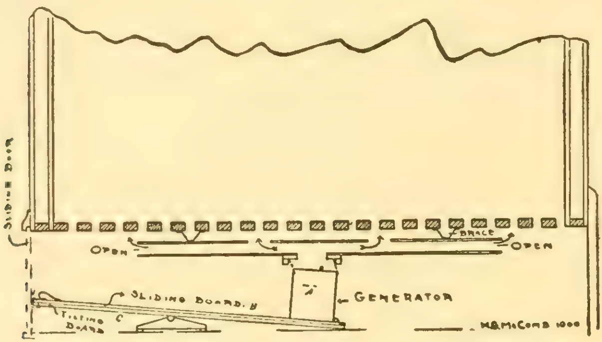

FIG. 68—LOWER PORTION OF FUMIGATORIUM, SHOWING SLAT FLOOR, IN CROSS-SECTION, AND GENERATING APPARATUS (AFTER SANDERSON)

pushed down the incline, there is no chance of the operator breathing the fumes. The arrangement is simple, and any one at all handy with tools can easily construct the whole apparatus.

The Delaware method.—As a result of the splendid work of Professors Sanderson and Penny, of the Delaware Experiment Station, many obscure points about the diffusion of the gas have been cleared up. Their experiments point to the utility of a slat floor. As a modification of the ordinary slat floor, to

secure better diffusion, an arrangement of the floor and generator, as shown in Fig. 68, is recommended. This provides for a slat floor, underneath which run smooth wooden tubes, three inches in diameter, along the diagonals of the room and opening into a hood placed at the center covering the generator. These tubes, extending from the center, two-thirds of the

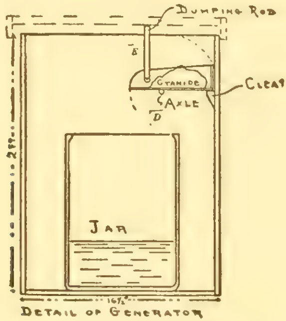

FIG. 69—GENERATOR AND DETAILS OF HANDLING IT (AFTER SANDERSON)

distance to the corner, are open at the ends, and one-third from the center, affording eight openings for the escape of the gas.

The bag of cyanide is placed on a shelf and the generator in the box, *A*, at the end of the sliding board, *B*. This board is pushed down the incline, *C*, and when under the board the outer end is pushed down and held in place by a sliding door. The shelf upon which the cyanide is placed rests on a pivot, as shown in Fig. 69 at *D*. Projecting upward from it is a rod, *E*, forming a trap. When the box is

thrown up beneath the hood the shelf is tipped and the cyanide dumped into the generator. This device is simple and cheap.

A good Western idea.—A Western firm has a novel and practical way of making an open floor and generating the gas underneath. They say: "Our fumigating house is 15 x 20 x 10 feet. The walls are double, of one-inch plank, the first course being put on lengthways of building, then common building paper, tarred after being put on. The second course of plank is put on up and down. This course is on the outside; roof made the same way; doors similarly made, are double, and take up one end of the building. After the building was completed, we banked up around the bottom about a foot with dirt; then we excavated about a foot and a half deep, one foot from the bottom of the walls. For instance, if the room was 10 x 20 feet, the excavation would be 9 x 19 feet, surface measure. Over this excavation is laid three 2 x 4 inch joists, just enough to hold the stock which is put in for fumigating. Across these joists lay two or three 12-inch planks, loose. This completes the house.

"An opening or flume is made under the wall about one foot deep and eighteen inches wide. The end extending into the inside of the building is open, and extends just far enough to let the gas into the excavation under the trees. The outer end extends out far enough to give the operator ample room to insert the vessel containing the chemicals. The outer aperture is covered with a trap-door. The vessel with the acid and water is set in the flume, trap-door open, and

the cyanide dropped in. The trap-door is closed quickly and is covered immediately with a piece of cloth (blanket is best), and dirt hurriedly thrown over the whole business. This prevents any of the gas from escaping, and makes the building absolutely air-tight, which is necessary. The gas fills the excavation and rises through the loose floor, permeating through the trees, filling the entire inside of the house. In our building we treat about five thousand trees at a time. For fall deliveries we treat the stock as it comes from the field to the packing-ground. For spring delivery we treat them as we take them from the healing grounds to the packing-grounds. The cost of our building did not exceed $50 complete."

CHAPTER XIII

PRACTICAL HINTS TO NURSERYMEN

THE amounts of chemicals necessary for a room are estimated in terms of cyanide per cubic foot of space enclosed. For example, let us suppose a room contains 564 cubic feet. We use 0.25 (twenty-five hundredths) gramme of cyanide for each cubic foot. We therefore multiply 564 by 0.25. Thus, $564 \times 0.25 = 141.00$ grammes of cyanide. To reduce this to ounces we divided 141.00 by 28.35, as there are 28.35 grammes in an ounce. Thus, $141.00 \div 28.35 = 5$ ounces (a fraction less), the amount of cyanide needed for the house. The other chemicals are easily determined, as a half more acid, liquid measure, than cyanide, and a half more water than acid are used. Thus, the room needs 5 ounces cyanide (by weight), 7½ ounces acid (liquid measure), and 11¼ ounces (liquid measure) of water.

As a rule, we discard any fraction less than a half. In this case, therefore, we would use 5 ounces of cyanide, 7½ ounces of acid, and 11 ounces of water. The cost of chemicals to fumigate this room, full of trees, would be about 11 cents. The amount of cyanide needed for any room can be determined in the same manner. First, see to it that the cubic contents of the enclosure has been accurately computed, then

multiply by 0.25 (twenty-five hundredths) and divide by 28.35, as indicated above, and you will obtain the correct amount in ounces. Always bear in mind that fumigation will admit of no guesswork, as success depends on accuracy.

Low-grade stock, as indicated in Chapter III., should not be fumigated with the 0.25 gramme formula. The 0.16 or 0.18 formula should be used for June budded peach or plum, low grade peach and plum, known as whips, and for scions, buds, grafts, etc. In using this formula, the cubic contents of an enclosure should be multiplied by 0.16 or 0.18, as the case may be, and reduced as above to ounces.

Cost of nursery stock fumigation.—It is difficult to ascertain the exact cost for fumigating young trees per thousand. The conditions under which the trees are grown and handled in most States varies considerably. In most cases, nurserymen who have had much experience along this line have found that the ordinary first-class grade of fruit trees can be fumigated at a cost not to exceed twenty-five cents per thousand trees. This amount includes the chemicals and extra labor in handling. However, the cost of the fumigating house or box is not taken into consideration. In many cases where a room can be filled with trees the cost of fumigation can be reduced from ten to fifteen cents per thousand trees, depending upon the grade and kind. It is often necessary to fumigate a small bundle of trees in a large room or enclosure. In such a case, the quantity of chemicals necessary to fill the

room is the same as if the entire enclosure was filled; therefore, the cost would be somewhat increased.

Small room a necessity.—Whatever may be the size of the nursery, a small room, say 4 x 5 x 7 feet, is a necessity. Very often a small order or a few trees to complete a big order are needed quickly. It would be poor economy to use eighteen ounces of cyanide, costing about forty cents, to fumigate a handful of trees in a large room, when one ounce, costing less than two and one-half cents, in a small room would answer the same purpose. It is not desirable, in most cases, to mix up small orders with car-load lots, and in most nurseries a small room will be found in almost constant use. The kind, shape, size, and location of the fumigating house rests entirely with the individual, and he must be the judge as to what is best suited for his purposes. One thing must be remembered at all times, whatever may be constructed, and that is, it must be gas-proof.

Preparation of trees.—The house having been constructed, the next step is the proper preparation of the trees for treatment. In the first place, care should be taken that the trees are thoroughly matured and dormant before they are dug and passed into the fumigating house. Nurserymen should heed carefully the cautions cited in Chapter III. Well-matured nursery stock should be dug in the customary way, tied in loose bundles, brought to the fumigatorium, and piled loosely, not packed, upon the floor, with the roots toward the walls and tops overlapping. The trees should be as dry as possible. They may be damp or

moist, but should not be drenching wet. Where only a few trees are fumigated, they are usually stood on the floor in bunches. When the desired number has been placed in the room, and the ventilators have been closed, they are ready for the gas. The chemicals are then prepared and placed, after which the doors are closed, and left the desired length of time. A half-hour is the minimum limit, but thoroughly matured dormant trees are not injured in the least if left an hour. The chemicals should be prepared and used strictly in accordance with the directions given in Chapter II.

Other materials needed.—A pickle jar or china dish holding from two to four quarts is best adapted for holding chemicals for the generation of the gas in ordinary houses. Sometimes a larger vessel, such as a snuff-jar, is needed. A liberal supply of small manila-paper bags holding a pound or more are necessary. Where the amount of cyanide needed is known, it can be weighed, placed in manila bags, and kept in an air-tight can or other enclosure ready for use. Care should be taken not to weigh too much cyanide at a time, as the bags become saturated with moisture if long exposed to the air. It is best to weigh the cyanide at night or early in the morning, or even during the noon hour, rather than have it standing around for several days. A glass beaker, holding from a pint to a quart, with a graduated scale on the side in ounces, will be required for the acid and water. A supply of acid should be kept in a carboy or other vessel. It should be drawn in an ordinary glass, china, or agate pitcher, as needed. For immediate use, a supply of

water, together with a cup or glass for dipping, should be kept close at hand.

Cellars and cars.—It is not desirable to attempt to fumigate trees after they are packed in cellars or cars. In some cases serious injury has been done when trees were fumigated in freight-cars after being packed. As a rule, the roots are so closely packed with moss and other materials when put in cars it is difficult for the gas to get to them. It is practically impossible to properly ventilate the car afterward, and more or less gas is left. The only proper place to treat trees is in the fumigatorium.

Canvas over wagon.—An enterprising nursery firm in Utah uses a canvas sheet over a wagon loaded with trees, in addition to the use of a house. They give the following description of house and method of handling tent: "For a number of years we used a small room about 12 x 12 feet. Finding this too slow a process, we put up a building 22 x 56 and 9 feet high. The roof and entire building is made with two thicknesses of 1 x 12 feet boards, with building paper between, which makes it very tight. As this was rather large for ordinary use, we made a partition, making the smaller room 22 x 20. This latter room we use mostly when we store our stock inside to be treated.

"We think, however, by far the better and more economical method is to do the fumigating on the wagon at the time stock is dug and hauled in. This is done by using a canvas sufficiently large to cover the entire load, with a few feet of margin, which should be spread on the ground and weighted down to keep the fumes

from escaping. In order to lower wagon, trenches should be made to allow wheels to drop down. Our canvas is 32 x 38 feet. This is a large sheet and unwieldly to handle unless parties know how it should be done. Our method is to place the sheet behind the wagon, doubling the front end back over the other. To the corners of the top canvas fasten poles long enough to clear the load. Fasten lines at ends of poles, and when ready to raise have men pull the ropes. The air will be of great assistance, and if quickly done the canvas will sail over without friction. Our experience has been that hydrocyanic acid gas properly applied is certain death to all insect life."

Points to remember.—1. Never let a tree go out of the nursery unless it has been fumigated.

2. Never fumigate a tree on which there is known to be a San José scale. The furnace, and not the fumigating house, is the place for such trees. A dead scale on the tree is just as demoralizing to the nursery business as a live one if seen by the buyer.

3. Never use the gas stronger than 0.25 gramme cyanide per cubic foot on any kind of nursery stock.

4. Never leave the trees exposed to the gas longer than an hour. Thirty to forty-five minutes is sufficient.

5. Never fumigate trees, especially peach, a second time.

6. Never fumigate trees in a car, box, or cellar after they are packed.

7. Never fumigate trees when they are drenching wet. They may be moist, even quite damp.

8. Never puddle the roots of trees before they are fumigated.

9. Never fumigate cedars and evergreen trees, unless there is some special reason for it.

10. Never fumigate trees until the wood is well matured and the buds are thoroughly dormant.

11. Never fumigate trees after the buds have begun to open in the spring.

12. Never fumigate June buds and peach under three feet with gas stronger than 0.18 gramme cyanide per cubic foot. Better use 0.16 gramme.

13. Never fumigate buds, grafts, or scions with gas stronger than 0.16 gramme.

14. Never leave the cyanide can where children can reach it.

15. Never let the cyanide can be without a conspicuous label, "Poison."

16. Never leave the cyanide exposed to air. It will absorb moisture and be ruined.

17. Never take a bag of cyanide out of a can unless you are all ready to use it.

18. Never leave the door of the fumigating room open a moment after the cyanide has been dropped in the jar.

19. Never allow a person to go near or open the door when fumigating trees or anything else.

20. Never allow anybody to enter a room under ten to fifteen minutes after the door and ventilators are open.

21. Never empty residue of jar where children would play in it.

22. Never allow residue to remain long in the jar.

22. Never put a new charge in a jar containing the old residue.

24. Never put sulphuric acid in tin or iron vessels; it will eat them up. Always use glass, earthenware, agate, or wooden vessels.

25. Never lose an opportunity to caution persons about the danger attending the inhalation of this gas.

CHAPTER XIV

GREENHOUSE AND COLD FRAME FUMIGATION

THE greenhouse problem in reference to insects has been one of considerable importance. Early in 1894 Dr. Albert F. Woods, assisted by Mr. Dorsett, as noted in Chapter III., began a series of experiments under glass with this gas. They found that plants were less injured by a short exposure to a relatively large amount of gas than they were by a long exposure of a relatively small amount. It was also shown that the stronger dose a short time was most destructive to the insects affecting the plants. In these experiments they showed that different species and varieties of plants varied remarkably in their power to withstand the gas, depending upon the open or closed condition of the breathing pores of the leaf, the cell contents, and temperature of the inclosure. The plants fumigated were ferns, coleus, double English violets, single violets, roses, carnations, grapes, tomatoes, and cucumbers.

The amount of cyanide used per cubic foot of space inclosed varied from 0.075 gramme to 0.15 gramme. For instance, ferns, infested with a scale insect, similar to the scurfy scale on apple, were fumigated at night with 0.075 gramme 98 per cent. cyanide for twenty minutes without injuring the most delicate fronds, at the same time destroying all the insects. In case of coleus, infested with mealy bug, in a very

large house (15,587 cubic feet), one-tenth (0.10) gramme cyanide was used. In case of the double English violets, infested with plant-lice, slugs, millipedes, leaf-eating larvæ, cutworms, red spiders, etc., fifteen hundredths (0.15) gramme was used, and exposed twenty minutes. All the insects were destroyed, excepting a few red spiders, and even these were kept down by frequent fumigation.

Effects on foliage.—The foliage of single violets, like California, Princess of Wales, and the like, is sometimes slightly injured with the stronger dose of 0.15; a weaker amount, one-tenth (0.10) gramme should be used for these single varieties. Roses, especially the younger growths, are very sensitive, and slight injury has been noticed even where the smallest dose (0.075 gramme) was used. Carnations will stand one-tenth (0.10) gramme for fifteen minutes; but more careful experiments are needed before the gas is generally recommended for either carnations or chrysanthemums.

Grapes, under glass, in New Zealand, have been fumigated at the rate of nine-hundredths (0.09) gramme over night, infested with mealy bugs, with good results. It has also been used successfully by Dr. J. Fisher on tomatoes infested with the white fly. He used one ounce cyanide (28.35 grammes) for 1,000 cubic feet, and left the plants exposed over night without injury. The writer fumigated a greenhouse in Maryland in which cucumbers were growing and badly infested with the melon louse (*Aphis gossypii*). The house was filled with gas at sundown, using fifteen-hundredths (0.15) gramme of cyanide per

cubic foot, and left until morning. The lice were all destroyed, and there was no perceptible injury to the plants. Indian corn, from ten to twelve inches high in pots standing in one end of the house for experimental purposes, was destroyed.

Preparation of the house.—The very poisonous nature of the gas must be considered. The cautions cited in Chapters III. and IV. should be heeded. The house should be made as nearly tight as possible under ordinary circumstances. The ventilators should be arranged so several of them can be opened from the outside. Plants that will not stand the stronger doses of gas, if in pots, should be removed. The room should not be fumigated immediately after the plants have been sprinkled or watered. The floor of the house should not be drenching wet, although it may be damp.

After estimating the cubic contents of the house, and the amount of cyanide is determined, the quantity needed can be figured out according to the directions given in Chapter XIII. for nursery stock. Care should be taken, however, to multiply the number of cubic feet by the exact fraction of a gramme. For instance, 0.25 gramme cyanide per cubic foot is used for well-matured and dormant nursery stock, and 0.20 gramme for orchard trees out-doors; but no such doses are used in greenhouses. Very good results have been obtained where 0.15 gramme cyanide per cubic foot has been used in greenhouses and cold frames for the violet aphis. For other insects and plants the amount of cyanide varies, as indicated above.

FIG. 70—METHOD OF FUMIGATING GREENHOUSE

How to prepare the jar.—The chemicals should be prepared strictly in accordance with directions given in Chapter II. An earthenware crock or jar will be needed, the size of the vessel depending upon the capacity of the enclosure. The number of vessels needed will depend upon the size of the house to be fumigated. In a small-sized house single jars may be sufficient, but as a rule it is desirable to use two or more crocks or vessels. After the acid and water have been mixed and placed in the vessels, the cyanide, which has been previously weighed and wrapped in strong manila paper bags, is suspended over the crocks, as shown in the illustration.

Several hooks or screw-eyes can be used conveniently to carry the string from the door to the vessels. There should be as many lines of string as there are vessels, each one leading to the door or outside opening. as shown in Fig. 70. If the building requires four pounds of cyanide and two jars are to be used, it is desirable to divide the cyanide into equal parts. Before the acid and water are placed in the jars, it is well to tie the bags of cyanide to the cords and see whether or not they work satisfactorily. Care should be taken to see that the bags when lowered will go into the crocks, and thus into the chemicals, without difficulty.

At times it is necessary to use some protection around the jars to prevent the injury of the foliage in case plants are too near. A section cut from a roll of building paper can be used to good advantage, as the paper rolls in a tube and can be placed around the vessel, thus keeping the acid and water from spattering

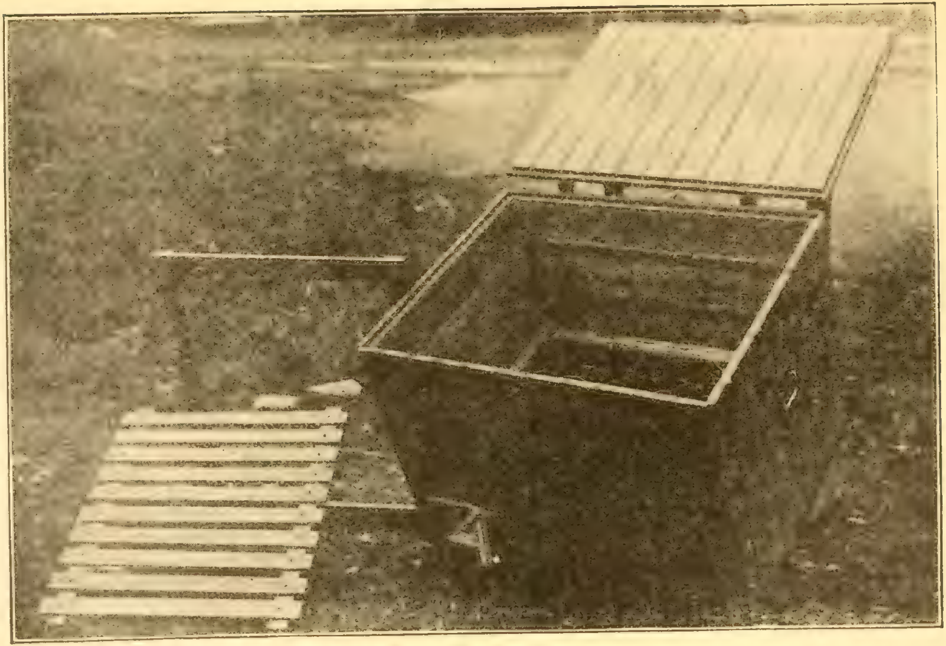

FIG. 71—BOX FOR FUMIGATING SMALL PLANTS AND CUTTINGS

on the surrounding plants. Paper used for this purpose can be rolled together, laid away, and is ready for future use. When everything is in readiness, doors and ventilators should be closed, and the cyanide lowered into the vessels by loosening the strings. The gas is given off almost immediately and a small quantity will leak out of the house; but if the room is reasonably tight the greater portion of it will be kept within for a time sufficient to destroy the pests. When the proper time has elapsed, varying, of course, for different plants, the ventilators should be opened from the outside, so that the gas can escape as rapidly as possible. After free circulation is obtained by opening the doors and ventilators, all traces of the gas will have disappeared from the house in from thirty to forty minutes. The house can then be closed if desired. The residue left in the jars should be emptied, as previously described.

Boxes for fumigating small plants.—Where it is desirable to fumigate several hundred small plants, small boxes, such as described in Chapter XI., can be used to good advantage. In most cases a special box, such as shown in Figs. 47 and 48, is desirable. The box should be as nearly air-tight as possible, with a removable cover or trap-door which can be quickly closed. A special box, shown in Fig. 71, was constructed and used by Prof. E. D. Sanderson for the fumigation of small plants. Small wire or slatted trays can be used to good advantage for the fumigation of cuttings, such as coleus and various other plants. Potted plants can be fumigated in the same box if necessary.

A plain wooden box, such as is shown in Figs. 49 and 50, or even a small Emory fumigator, as seen in Figs. 33 or 36, will be found very useful to florists and gardeners in any greenhouse or nursery grounds. This box can be used for the fumigation of small shrubs and plants on lawns, in gardens, and various other places where it is desirable to fumigate them without taking them up. The box may be used in the daytime if the work is done in a cool place. Some florists and nurserymen use small boxes in their packing-houses and cellars where the temperature is constant. Care must be taken, however, where the gas is generated and released in such places, to see that proper ventilation is secured to carry away the poisonous fumes when released from the box. Nurserymen handling ornamental plants can use their fumigating houses for the treatment of various shrubs. Some florists have found that a small greenhouse containing 1,000 feet or less is more reliable than a box. There is less danger of injury to the foliage under such conditions.

Experience with various plants.—Although a large number of greenhouse plants have been fumigated, there is yet room for much careful experimental work. The following list of plants, given by Dr. Woods, have been fumigated.

Ferns.—For *Davallia mooreana*, infested with a scale insect (*Chionaspis* sp.), 0.075 gramme of 98 per cent. potassium cyanide should be used for each cubic foot of space to be fumigated, not deducting the space occupied by the plants. Length of exposure, twenty minutes.

One hundred and fifty to two hundred plants with fronds in all stages of development have been thus treated two or three times each year for the past four years with no injury to the plants and almost complete destruction of the insect. They were treated fifty at a time in a fumigating box.

Adiantum cuneatum and *A. ballii* have been tried on a small scale and were not injured by the treatment.

Coleus.—Golden Bedder, Verschaffeltii, Shylock, and others; 24,000 plants in pots, badly infested with the white-tailed mealy bug, *Orthezia insignis.* The house contained 15,587 cubic feet of space. Treated at the rate of one-tenth of a gramme of 98 per cent. cyanide of potash per cubic foot of space for twenty minutes, one hour after dark. Orthezia all killed and plants not injured in the least. All other means of destroying the Orthezia had been tried without effect. Large numbers of the common mealy bug were also killed by this treatment; but it was not nearly so effective as for the white-tailed mealy bug. All coleus cuttings made by the United States Propagating Gardens for the past few years have been fumigated before being prepared for the cutting bed.

Double English violets.—Marie Louise, Lady Campbell, and others. For plant-lice and general fumigation fifteen-hundredths of a gramme of 98 per cent. cyanide of potassium for each cubic foot of space is required. The exposure, if made according to directions, will not hurt the plants in any stage of growth. The gas has been used on a large scale in fumigating violets for the past three years with the greatest suc-

cess, only a few treatments during the season being required. Leaf-eating larvæ, slugs, millipedes, cut-worms, etc., when exposed are killed as well as plant-lice. Red spiders, however, are not entirely eradicated by the treatment. The foliage of single violets, like California and Princess of Wales, are sometimes slightly injured by the stronger dose of gas. A weaker dose, one-tenth of a gramme potassium cyanide per cubic foot, should be used when they are to be treated.

Other plants.—Other plants on which the gas has been tried on a small scale indicate that it may probably have quite a wide range of usefulness. It has been used on the following plants at the rate of one-tenth gramme of cyanide per cubic foot of space for twenty minutes without injury. Further experiment, however, is necessary before the treatment can be recommended for these: *Alocasia macrorhiza variegata; Anthurium crystallinum; Areca lutescens; Aralia filicifolia; Adiantum cuneatum; Adiantum ballii; Campylobotrys refulgens; Cissus discolor; Crotons* (in variety); *Cichorium intybus; Diffenbachia lenmannii; Ficus elastica; Fuchsias* (in variety); *Jacaranda mimosæfolia; Marantas* (in variety); *Nymphæa candidissima*, and *odorata rosea; Pontederia crassipes; Pandanus veitchii; Phrynium variegatum; Phyllotænium lindenii; Panax victoriæ; Stenanthium lindenii.*

Roses.—Perle des jardins, Mermet, and Bride. The young growth on roses is particularly sensitive, and has been more or less injured in all our experiments.

Carnations.—Scott, Garfield, Meteor, and Mc-

Gowan will stand one-tenth of a gramme of 98 per cent. cyanide per cubic foot of space for fifteen minutes without material injury. This will kill about 90 per cent. of the plant-lice, but will not kill thrips. The use of the gas for carnations needs to be more carefully investigated before it is recommended. The same is true of chrysanthemums, on which it has been tried with only partial success, the young growth being very sensitive.

Grapes under glass.—The gas has been used with success in New Zealand for the mealy bug, *Dactylopius adonidum* L, at the rate of one-third of an ounce 98 per cent. cyanide to 100 cubic feet. This is equivalent to nine-hundredths gramme per cubic foot. The gas is liberated after dark and left in till next morning, when thorough ventilation is given. It largely escapes, however, during the night. The treatment is said not to injure the plants in the least.

Tomatoes.—Dr. J. Fisher, on October 29, 1898, reports using the gas for white fly (*Aleyrodes* sp.) on tomatoes. The gas from one ounce of pure cyanide of potassium for each 1,000 cubic feet, left in the house over night, killed all the insects without injury to the plants. This method should receive careful trial by other experimenters.

Other experiments in greenhouses.—For some years in the large greenhouses connected with the Massachusetts Agricultural College considerable difficulty has been experienced with mealy bugs and various species of scale insects on large vines, palms, begonias, orange trees, acacias, etc. After a thorough trial of

numerous insecticides, hydrocyanic acid gas was used. The work was placed in the hands of H. D. Hemenway. All the results obtained were not conclusive, and it is impossible to give definite details relative to future work. Some of these results, however, are interesting, and are given herewith. Other tests should be made.

After several preliminary experiments with some of the more delicate plants in a wooden box, two rooms, known as the stove and cactus, were fumigated at the same time, the connecting doors between them having been opened. Many of the cacti were infested with the common cactus scale, *Diaspis cacti*. In the stove-room, all through the twining vines, were white waxy threads protecting the eggs and young mealy bugs.

The cactus-room contained 7,076 cubic feet of air space and the stove-room 7,357 cubic feet. Forty ounces of potassium cyanide were used in each room, and they were kept closed for thirty minutes. The ventilators, which had been previously prepared, were then opened from the outside. The temperature of the house was about 60° F. The conditions of the weather were perfect for such a test, as it was raining, the water filling all the cracks in the house, and thus preventing the escape of the gas. It was also warm outside, so the house was not cooled too low while the ventilators were open. It was perfectly dark. The ventilators were left open for about an hour, and closed for the night.

The room contained many different kinds of cacti, begonias in variety, passifloras, allamandas, bananas

in fruit, ferns, palms, and a large variety of general stove plants. Not only were the mealy bugs, scales, and aphides destroyed, but a large per cent. of sow bugs were found dead on the walks and under the moss which covered the floor of the solid bed in the stove-room. Even the earthworms on the surface of the soil under the moss were dead.

Another house containing 22,729 cubic feet of space was fumigated, using one ounce potassium cyanide to every 285 cubic feet. It contained carnations, smilax, violets, coleus, chrysanthemums, small lettuce, cuttings, and small plants of bedded stock. It was infested with the common mealy bug, *Dactylopius destructor*, green fly, and the white-tailed mealy bug, *Orthezia insignis*. It was fumigated for thirty minutes upon a cloudy morning, yet in daylight. The insects were mostly killed, but some of the plants were badly injured. This was especially true in case of the smilax, the upper leaves of carnations and lettuce. Much of the latter, which was very small and in full light, was killed, while some that was shaded showed much less injury. The smilax and carnations recovered in time, but received a severe check. Smilax and more delicate plants have been subjected to double this strength of gas by the writer, in darkness, without injury.

About the middle of January a camellia-room was fumigated with one ounce potassium cyanide to every 3,000 cubic feet. The room contained 6,196 cubic feet, and 2.06 ounces cyanide were used. It was fumigated at night about six o'clock, and remained closed until morning.

The insects present were green fly, mealy bug, and Fuller's leaf beetle. The plants were coleus, azaleas in bloom, heliotrope, ferns, hoya, jasmins, polygala, hibiscus, ericas, orange trees, camellias, cinerarias, and oxalis. The temperature went below 50° F. No plants were injured. Part of the green flies were killed, but mealy bug and leaf beetle were not injured.

Another trial was made in the camellia-room just mentioned a few days later with gas generated from one ounce cyanide to 2,000 cubic feet of space. The exposure was continued throughout the night. No plants were injured. The green flies were all killed, but only a few of the mealy bugs were destroyed.

A few days later another test was made in the same room, using one ounce cyanide for each 1,000 cubic feet. The temperature of the room was slightly above 50° F. With the exception of heliotrope and coleus, the plants were the same as used in the two previous tests. All the mealy bugs were destroyed. It would seem from these tests that the gas can be used in a greenhouse, under such conditions, generated from one ounce cyanide in 1,000 cubic feet of space, with good results upon the common mealy bug.

Many other tests were made, including the vegetable house. The cyanide was used at the rate of one ounce for each 3,000 cubic feet of space enclosed. The temperature was about 56° F. The plants fumigated were lettuce, radishes, papyrus, smilax, cinerarias, and kale. The lettuce and cinerarias were badly covered with green fly. Nearly all green fly was killed, even under the lower leaves of the lettuce which had commenced to head. There was no injury to plants.

Estimating cubic contents.—The following excellent method for determining the cubic contents of a greenhouse has been suggested by Dr. B. T. Galloway: In all cases where fumigation with this gas is to be followed it is necessary to first determine accurately the cubic contents of each house. The determination of the

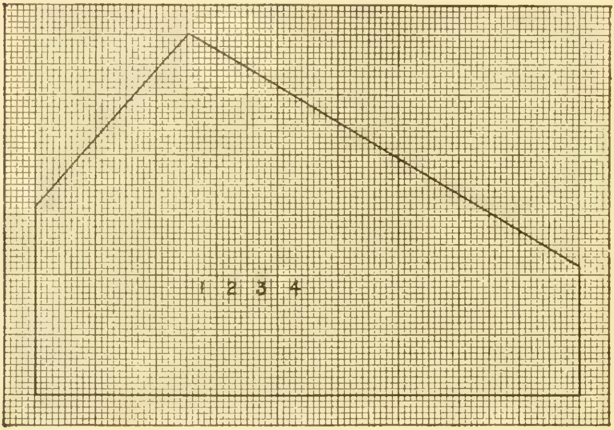

FIG. 72—DIAGRAM ILLUSTRATING METHOD OF DETERMINING CUBIC CONTENTS OF GREENHOUSE. (AFTER GALLOWAY)

cubic contents of the house, while in itself a comparatively simple problem, has, in the eyes of many growers, difficulties which they are not willing to undertake. The cubic contents can be determined by a comparatively simple mathematical calculation, but perhaps the easiest way is by the square method. This involves nothing more difficult than the mere counting of a number of squares. On examining Fig. 72 the simplicity of the method will become

apparent. Procure from a stationery store or art supply store some cross-section paper, such as represented in the figure. In this particular case squares of three sizes are shown, the largest being one-half inch, the next one-fourth inch, and the smallest one-sixteenth inch square. The one-fourth inch squares may represent feet. Now determine the dimensions of the house, that is, the length, width, hight to ridge, and hight on sides, and make a sketch as shown, each square or one-fourth inch representing 1 square foot. This particular house, it will be seen, is 18 feet (18 squares) wide, 12 feet to the ridge, 6½ feet high at the back, and 4½ feet high in front.

The ridge stands 5 feet from the back wall, as shown in the sketch. After the lines are drawn, simply count the squares inclosed, and the number of squares will be the number of square feet. The parts of squares, that is, where a line divides a square, can be easily determined by counting the smallest squares, or by the eye, and by adding these fractions of squares together the number of whole squares may be readily found. After the number of square feet is obtained it is only necessary to multiply this by the length of the house in feet and the result will be the cubic contents. For example, supposing the house in question is 100 feet long, it contains 150½ squares or square feet, and 150½ multiplied by 100 equals 15,050 cubic feet. The whole operation requires less time than it takes to describe it, and will apply, of course, to a house of any shape or size. It may be added that if the cross-section paper can not be obtained readily the sections or squares can be laid off with a rule and lead pencil

and practically the same results obtained. In any event, it is only necessary to get an accurate outline drawing of the section of the house, and by projecting this over squares as indicated the number of square feet in the section can be readily determined.

The cubic contents of the two styles of greenhouses shown in Fig. 73 are easily estimated, according to the following scheme by Professors Woods and Dorsett. At the left is an even span house 100 feet long, 12 feet wide, 2 feet on the sides, and 5 feet 6 inches from the

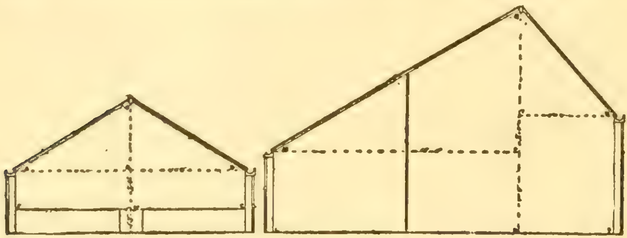

FIG. 73—EVEN AND THREE-QUARTER SPACE HOUSES AT LEFT AND RIGHT—END SECTIONS. (AFTER WOODS AND DORSETT)

the surface of the beds to the ridge, with a walk 14 inches wide and 15 inches deep. To determine accurately the number of cubic feet in a house make a rough drawing showing a cross-section, and divide the space into triangles and rectangles by drawing a line connecting the two wall plates and one from the ridge at right angles to this; mark on each its respective length in feet and inches. Compute the number of cubic feet in each of the rectangles and triangles. In the even span house, shown at the left, the number of cubic feet of space in the walk is found by multiplying the width by the depth by the length, thus: Multiply

1 foot 2 inches by 1 foot 3 inches by 100 feet; reducing to inches, we have 14 inches multipled by 15 inches by 1,200 inches equals 252,000 cubic inches; dividing this result by 1,728, the number of cubic inches contained in a cubic foot, we have 145.83 cubic feet. The rectangle *A D G F* is computed in the same way, except that in this case it is not necessary to reduce the feet to inches. It would be 12 feet multiplied by 2 feet by 100 feet equals 2,400 cubic feet.

The rule generally given for calculating the area of a right-angle triangle is to multiply the base by the perpendicular and divide the product by 2. The result multiplied by the length of the house will give the number of cubic feet the triangular portion contains. For example, taking the triangle *A C E*: 6 feet multiplied by 3.5 feet equals 21 feet, divided by 2 equals 10.5 feet, multiplied by 100 feet equals 1,050 cubic feet. The area of the triangle *E C D* and the cubic feet in this part of the house are determined in the same way; or, in this case, since the triangles are equal, the desired result is obtained by multiplying the number of cubic feet in the triangle *A C E* by 2; 1,050 multiplied by 2 equals 2,100 cubic feet. The contents of this house is therefore 145.83 plus 2,400 plus 2,100 equals 4,645.83 cubic feet; this result multiplied by the required dose per cubic foot of space will give the amount of cyanide of potassium necessary for one fumigation.

At the right, in Fig. 73, is a cross-section of a three-quarter span house 100 feet long, 18 feet wide, front wall 4 feet 4 inches, back wall 6 feet 4 inches, and 1 feet 10 inches to the ridge. The cubic contents of this

house is determined in the same manner, except that the two triangles being unequal, each one will have to be calculated separately. The house contains 15,050 cubic feet. It will thus be seen that the cubic contents of a house or frame of any style can be readily determined by simply dividing a cross-section of the same into the necessary number of triangles and rectangles, and calculating as demonstrated above.

Cold frames.—That cold frames can be successfully fumigated has been shown by recent practical work. Make the frames as nearly air-tight as possible, and cover them with blankets or canvas if necessary. Estimate the cubic contents of air space inclosed, and then calculate the amount of cyanide necessary. For example, suppose a frame contained 567 cubic feet. Multiply this by 0.15, an equivalent of 0.15 gramme cyanide per cubic foot. Therefore, 567 x 0.15, equals 85.05 grammes; reduced to ounces by dividing by 28.35, as there are 28.35 grammes in an ounce, gives (85.05 divided by 28.35) 3 ounces the amount of cyanide required.

This inclosure would require 3 ounces cyanide, 4½ ounces sulphuric acid and 6¾ ounces of water. After the cyanide is determined it is easy to estimate the acid and water. Use a half more acid, liquid measure, than cyanide, and a half more water than acid. Weigh the cyanide and wrap it in paper or a bag. Measure the acid in a glass beaker, marked ounces on the side, and pour it in an earthern jar or china bowl; measure the water and pour upon the acid. When everything is in readiness drop the cyanide, paper and all, into the liquids and close the frames quickly.

Leave exposed twenty to thirty minutes, and no longer. Do the work on a dark, cloudy day, or late in the evening, or at night. Thoroughly air the frames afterward, and empty the residue in the jars. Do not inhale the gas, and do not handle the cyanide carelessly. Both are deadly poison if breathed or swallowed.

General summary.—(1) The cubic contents of the house and the amount of cyanide to be used should be carefully determined. (2) The enclosure should be made as nearly gas-tight as possible. (3) The ventilators should be arranged so as to be opened from the outside. (4) Place the screw-eyes in their proper places and run the string through them. (5) Determine whether the bag of cyanide is directly over the jar before the chemicals are placed in it. (6) Measure the acid and water carefully, place it in the vessels, hang the bag of cyanide directly over them, and arrange the protection sheets of paper. (7) The bags should be lowered by loosening the string from the outside door. (8) Doors should be properly closed and left locked the desired length of time. (9) After proper exposure open the ventilators and doors from the outside, and leave them thirty or forty minutes before entering the house. After that time they can be closed and left until morning. (10) The contents of the jars should be buried or thrown upon a manure pile. (11) Jars should be thoroughly washed with cold water and set away for future use.

A practical application.—In reply to a recent letter, Edward A. Moseley, of Washington, D. C., says: "I most certainly believe cyanide fumigation is practical.

Last year in my largest house I only found it necessary to fumigate once, and until the violets were thrown out this spring I never saw another aphis in it. I cannot now give you exact information in regard to the cost of fumigation.

"I do not entrust the operation to any one, as the risk, which I believe to be great, I take myself. Therefore all the fumigation which I have done I have done alone, except with a friend to assist; but the people who work about the house have nothing to do with it. Fumigating is done about an hour or two after dark. I grow Farquhar, Lady Campbell, and Imperial violets; also a few La France. Last year I had some of them in one house. The leaves of the La France were slightly injured by an exposure of twenty-one minutes.

"The black aphis were very prevalent; in fact, the plants were completely covered with them when I gave the application of which I have spoken, but it cleaned them out. I have used it also in violet frames and in a mushroom house. In the latter case I used it with great strength. I found mice, snails, roly-polys, and earthworms dead in the morning. This I put in and allowed to stay all night. I have also found from experiments that nothing can breathe the gas and live.

"In my opinion no one can successfully grow violets, at least in this vicinity, who does not use the gas. I have now one house 23½ feet wide by 200 feet long, one 20 feet wide by 100 feet long, one 12 feet wide by 60 feet long, all devoted to the growing of violets."

CHAPTER XV

SMALL FRUITS AND PLANTS

SOME method of destroying plant-lice, leaf-folders, and other insects on small plants has long been sought by economic workers. These pests can not be reached with sprays, and the application of certain gases seemed practical. In the spring of 1898 the writer began a series of experiments with hydrocyanic acid gas on strawberry plants to determine the strength that could be used with safety for the destruction of the root-louse, *Aphis forbesi.* In these tests it was shown that strawberry plants, dug in the spring, could be fumigated successfully before being transplanted. It was found also that the plants could be dipped in soap and tobacco solutions with fair results, but the process was slow, expensive, and difficult. The gas remedy was cheaper, more certain, and easier to apply.

Amount of gas for strawberry plants.—With the ordinary run of strawberry plants as they are taken from the nursery, two-tenths (0.2) gramme cyanide per cubic foot, exposed fifteen to twenty minutes, will be effective in killing the lice without injury to the plants. The roots should be as free as possible from dirt, and the plants should be reasonably dry. There is always more or less moisture on young plants, but under no circumstances should they be drenching wet at time of fumigation. Plants should not be closely

packed, but laid loosely upon trays in the fumigating box or room. The details of making and handling the gas are the same as that for nursery stock and greenhouse work. The apparatus to be used will depend upon the number of plants grown and handled annually. A convenient box for fumigating strawberry plants is shown in Fig. 71.

Experimental and practical tests.—At the Delaware Experiment Station a very complete series of tests were started by Prof. G. Harold Powell and completed by Prof. E. Dwight Sanderson. Several infested plants were fumigated and placed in paper bags, where they were left and examined twelve hours later. The following amounts of cyanide were found sufficient for the destruction of the root-louse: One-tenth gramme (0.1) per cubic foot space, exposed twenty minutes; fifteen-hundredths (0.15) gramme for fifteen minutes; two-tenths (0.2) gramme for ten minutes; three-tenths (0.3) gramme for five minutes. In the same series where 0.3 gramme cyanide was used, all the lice were killed where the exposure was only five minutes. It is not desirable to use these larger amounts even for a short exposure. The work by Professors Powell and Sanderson corroborates the various tests of the writer that the two-tenths gramme formula is satisfactory when properly handled. Under some circumstances a few lice may be secreted among the crown leaves and possibly escape where large numbers of plants are fumigated. This danger can be overcome largely by loose packing before fumigation.

Practical tests.—Early in April Professor Sanderson

fumigated 12,000 Bubach, Excelsior, and Johnson's Early strawberry plants. These had been packed in moss while *en route* from the nursery for nearly a week, but were in good condition. About 4,000 Tennessee Prolific just dug were also fumigated. The roots were cut back and fumigated in lots of 1,500 to 2,000 for ten minutes with two-tenths (0.2) grammes cyanide per cubic foot. The plants were set at once after fumigation and were not watered. They made a good stand, very few dying—so few that there was no question that the gas had done no injury, as two check rows were left which made no better stand. April 20th over 10,000 Bubach plants were fumigated. These had been dug for one or two days and packed in a barrel. They were quite wet when fumigated. About 8,000 were fumigated with one-tenth (0.1) gramme cyanide per cubic foot for ten minutes, and 1,500 at same dose for fifteen minutes, while nearly 1,000 were planted unfumigated as a check. After these plants were fumigated they were aired five minutes, roots dipped in water, and repacked in barrels. They were set out three days later. The plants showed no injury from the gas, all making an equally good stand.

In the experiments of Professor Sanderson the earth was firmly packed around the open bottom of the box used. The plants were well cleaned of earth, laid on trays, the bundles being cut open and thoroughly loosened. The lid of the box was then closed and fastened. A coffee cup or similar vessel was placed in the lower corner of the box by the door, and into it was first dropped a vial containing a proper amount of the cyanide in solution. A vial containing the sulphuric

acid was then dropped in and the door quickly closed. The vials were dropped in with the mouths down, and the contents drained out gradually, avoiding a puff of the gas by too rapid generation. The box was kept closed for ten minutes, or as long as desired. Both doors were then thrown open and the trays lifted out, so that the plants were thoroughly aired.

The cyanide solution should be secured from a druggist, put up in homeopathic vials, one dose in each vial. The solution consists of 100 grammes 98 per cent. potassium cyanide dissolved in water to make 200 cubic centimeters solution. The amount necessary for each dose is easily computed: multiplying the cubic contents of the box by 0.4 will give the number of cubic centimeters of the solution to be used, this giving a strength of 0.2 gramme potassium cyanide per cubic foot. Use an equal amount of sulphuric acid, which can be readily measured into empty vials. Thus for a box 2 x 2 x 2½ feet, or 10 cubic feet, 4 cubic centimeters of the solution, or a two-drachm vial half full, and an equal amount of sulphuric acid (best grade commercial, 1.85 specific gravity) would be used for a strength of 0.2 gramme potassium cyanide per cubic foot, or the same vial three-quarters full for a strength of 0.3 gramme potassium cyanide per cubic foot.

Small plants in the field.—For individual plants, such as melon, cucumber, cabbage, etc., a small cover is needed. In many cases where only a few plants are to be treated, a two-gallon wooden pail or other similar vessel will do. Paper or canvas covered boxes, one or two feet square at the base, and fifteen to twenty inches high, can be made cheaply and used to good

advantage. In his experiments Professor Sanderson used small paper covers, pyramidal in shape, the apex being eight inches high and fastened to the inside of a wooden frame three inches high by twenty inches square. The lower edge of the frame was beveled on the lower edge and could be easily pressed into the soil. A good quality of building paper, cut in one piece, can be used as covers. The cost of the covers complete should not exceed four cents each.

After making over seventy-five tests Professor Sanderson is of the opinion that about four-tenth (0.4) gramme cyanide per cubic foot exposed ten minutes is sufficient. In some tests young cantaloupes, fumigated immediately after a shower, were somewhat injured. The plants should be as dry as possible and the amount of cyanide reduced to three-tenths (0.3) gramme per cubic foot in some cases. The seemingly large amount of gas used on these low-growing plants is due to the fact that a larger proportion is lost in the small covers than in a large enclosure. Where plants are 5 x 5 feet apart, the cost of fumigation per acre, even at the maximum amount, is about seventy-five cents for chemicals. Two men with one hundred covers should fumigate from three to five acres per day, depending somewhat on conditions.

Plants in rows.—The fumigation of plants in rows is rather difficult and expensive. To compensate for the influence of soil and foliage, a larger amount of gas per cubic foot of space must be used to accomplish the same results than in a box or other enclosure. Prof. C. L. Penny, chemist at the Delaware Experiment Station, has shown conclusively by analyses that

when the gas is used in an elongated space the amount of cyanide per cubic foot is no guarantee, on the one hand, of sufficient acid vapor to do the work, nor, on the other, of too little to injure the plants. These tests show also that a large amount of gas may be absorbed by the film of water on damp foliage, or by the soil in a frame with the bottom open.

In field tests, therefore, a larger amount of gas than that used in the laboratory in a closed box was required to compensate the influence of soil and foliage. In a ten-foot frame, triangular in cross-section, with a cubic capacity of 8⅓ feet, or a ratio of 2½ soil surface to one of volume, Professor Sanderson found just twice as much gas was required to be generated from two points to be effective as that in a wooden box containing 10 cubic feet capacity and 5 square feet soil surface, having an almost opposite ratio of two of volume to one of soil surface. The materials and cost of constructing frames for the fumigation of plants in rows is slight. Frames, triangular cross-section 10 feet long by 10 inches high and 24 inches wide at the bottom, have been found very satisfactory by Professor Sanderson. With twelve such fumigators an acre of plants, where the rows are three feet apart, can be gone over in about two days. The cost of chemicals, not including labor, would be about three dollars per acre.

CHAPTER XVI

APPLICATION IN MILLS, ELEVATORS, AND OTHER ENCLOSURES

MANY gases and other materials have been used in mills and other enclosures for the destruction of insect pests. Gas generated from sulphur is not only dangerous to inhale, but is liable to injure manufactured products. The writer reported several years ago the serious results upon manufactured products in a mill where sulphur fumes were used. Smoke or fumes generated from tobacco are not desirable on account of the disagreeable odor and the after-effects upon grain and the manufactured products. Both of these materials being generated with fire, the danger attending application in mills and other places is increased, and their use is seriously objected to by insurance companies.

On the other hand, carbon bisulphide has many advantages over sulphur and tobacco ; it can be used without danger of injuring either the grain or manufactured products, and is generated without the use of fire. Yet many insurance companies will not permit their patrons to use it, except at their own risk, on account of its explosive nature when the fumes are mechanically mixed with air. It is, perhaps, the safest and most reliable remedy suggested for use in buildings and other enclosures where large quantities of grain and other materials are stored, due largely to the fact that its fumes are heavier than air.

Sometimes it is desirable to use carbon bisulphide

in connection with hydrocyanic acid gas in buildings and other enclosures. On one occasion the writer had a large quantity of grain badly infested with insects stored in an old building. The wheat was confined in several large rooms more or less open. Carbon bisulphide was used liberally for the destruction of the insects in the grain, but it was found that a large number of the creatures in the upper part of the building escaped, owing to the openness of the enclosure. The building was made as tight as possible by hanging blankets, fertilizer bags, etc., over the cracks, and a charge of hydrocyanic acid gas was liberated. Double the quantity ordinarily recommended for a tight enclosure was used. The experiment was largely successful, and the insects were thoroughly destroyed both in the grain and throughout the building. It is not desirable, however, to generate the two gases at the same time. In this instance the hydrocyanic acid gas was applied forty-eight hours after the carbon bisulphide was used.

The strongest arguments in favor of hydrocyanic acid gas are: (1) it is generated without fire; (2) it is comparatively cheap; (3) non-inflammable and non-explosive when generated with normal amounts; (4) does not injure grain or manufactured products, machinery, furniture, or equipment of any kind; (5) leaves no odor or residue after fumigation; (6) is lighter than air, and quickly permeates all cracks and crevices in which pests hide; (7) can be used at night or in the daytime at pleasure; (8) creates a death atmosphere in which no animal can live, including rats, mice, and other vermin; (9) its very deadly nature

when inhaled lessens the possibility of accident, and (10) it affords insurance companies and others all the protection possible under such conditions.

First use of hydrocyanic acid gas in mills, etc.—The use of hydrocyanic acid gas for the distruction of insects in mills, elevators and other large enclosures where grain is stored and manufactured was first suggested by the writer in an article in the *American Miller* for March, 1898. Up to that time, we believe, no attempt had been made to fumigate large buildings with this gas for the destruction of vermin. In this article attention was called to a large mill in North Carolina, overrun with cockroaches, and the following statement was made: "We are going to try a new remedy. It has never been used, to my knowledge, for destroying insects in mills. It is simple and easy to apply, but a very dangerous and deadly poison, and must, like dynamite, gunpowder, kerosene, or carbon bisulphide, be handled cautiously and by expert hands. Our new remedy is hydrocyanic acid gas, one of the most deadly poisons known. I have used this gas in my experimental work the past two years for killing insects upon young fruit trees, nursery stock and in bearing orchards, and in buildings for destroying rats, with marked success. I will now apply it to the modern mill and storehouse, and my candid belief is that it will be one of the coming remedies for all vermin, including rats and mice, within such enclosures."

The opportunity did not offer itself at the time for the experiment and we were obliged to let the matter drop. The spring of 1899, however, offered us a

chance to use the gas in a granary and storehouse. The results were so gratifying we decided to apply the same methods to a modern mill, if an infested one could be found and the owner would consent to the experiment. Two infested mills where we could try the gas on a large scale were soon found. Both contained three stories with basement and attic. One was 70 by 40 feet and the other 50 by 50 feet. Before filling an entire building with the gas, we decided to confine our experiment to one floor. All arrangements were made with a Pennsylvania miller and final directions were sent for the work. The first charge was set off June 10, 1899, using five pounds of potassium cyanide, an equivalent of 0.10 gramme cyanide per cubic foot of space enclosed.

Five days later the following letter was received from the owner: "We made use of the chemicals sent us, as directed, on the 10th instant, and had some success, at least enough to convince us that through its use we can retain possession of our mill. Most of the weevil on the first floor are either on the floor or very close to it, and we find that a good many of them escaped punishment. In the rooms above the first floor we will have a better chance at them, they being higher up in places where we can not get at them with anything but gas. We would like to have you arrange to send us enough of the potassium cyanide to go through our mill from the first floor up. Any information you can give us concerning the second treatment will be greatly appreciated. We found a dead cat on the mill floor when we went in after airing the room thoroughly."

This experiment was thoroughly satisfactory, and being the first of the kind ever tried in a mill, so far as known, was of special importance. Where only a single floor is fumigated, we would naturally expect some insects in the floor and beneath it to escape, as the gas is lighter than air and rises. A room, therefore, would have to be perfectly tight, and enough gas generated to fill it before the fumes would reach the floor and penetrate the cracks and crevices. It would be only a few moments after fumigation before insects would again come through the cracks in the floor from the basement below and perhaps the floor above.

To be successful in the greatest degree the mill should be thoroughly filled at one time with the gas. For instance, if only a single room or floor is used and the gas is generated, the insects become very uneasy when they begin to feel uncomfortable, and run here and there in search of a crack through which to escape; but if every room is full of gas there is no possible means of escape, except through some crack leading outdoors.

Second experiment in mills.—In an Ohio mill, June 20, 1899, we tried another experiment on one floor only, using ten pounds of cyanide at the rate of 0.12 gramme per cubic foot of air space. The chemicals were placed, according to my directions, in the hands of an expert chemist. June 30th the owner sent a sample of web and material from the room, and wrote me as follows: "I send you by mail, under separate cover, a sample of moth, weevil, and bugs the gas destroyed. I wish to thank you for what you

have done for me and to tell you that the experiment was a grand success."

A careful examination of the material sent showed seven species of dead insects, as follows: (1) Flour moth, *Ephestia kuehniella*, adults and larvæ; (2) bolting-cloth beetle, *Tenebroides mauritanicus*, adults; (3) American meal worm, *Tenebrio molitor*, adults; (4) flour weevil, *Tribolium confusum*, adult and larvæ; (5) black carpet beetle, *Attagenus piceus*, adult; (6) a lady beetle, and (7) a hemipterous insect. The latter two were, no doubt, feeding upon some soft-bodied creatures, as they are both predaceous. This web, flour, dust, and insects was placed in a breeding-cage and was under daily observation for three weeks and no life made its appearance. When the package was received one living specimen of the flour weevil, *Tribolium confusum*, was found. It was, no doubt, a straggler from some crack where the death atmosphere did not reach.

From recent results we are convinced that this gas is one of the most powerful and penetrating materials ever used in a mill or other buildings for the destruction of vermin. It diffuses so readily that it will permeate all parts of a mill or enclosure in a few minutes. It is a deadly poison if inhaled by a human being, it is true, but there is no necessity of one breathing the fumes if the proper precautions are taken. The writer is satisfied that by its use many a miller can retain possession of his mill who would otherwise be obliged to give it up and acknowledge, in the "struggle for existence," it is the ' survival of the fittest" that wins out. It is humiliating, indeed,

to be forced to concede that the flour moth or weevil is the fittest thing in existence, but some millers have actually been forced to abandon their mills on account of these insect foes.

Necessary preparations.—In fumigating a mill, elevator, warehouse or other enclosure containing stored grain or manufactured products, several things are to be taken into consideration.

1. The nature of the structure has a great deal to do with the effectiveness of the remedy. As the gas is lighter than air and very penetrating, it would soon escape and lose its deadly effect upon animal life in a building more or less open.

2. The weather conditions have to be considered. It is not desirable under any circumstances to fumigate an enclosure when the wind is blowing. A calm, quiet day or night should be selected for the work.

3. The building should be made practically gas-tight by closing up all the cracks and external openings. This can be done best by pasting strips of ordinary paper over the cracks. Special attention should be given to windows and doors, and they should be thoroughly secured before the gas is generated.

4. There should be no lights or fire in the building while it is filled with gas. It is non-explosive when used according to normal dose; but to preclude possible accident it is best to be on the safe side, thus this suggestion.

5. In a mill all machines, chests, spouts, elevators, elevator legs, bins, barrels, boxes, etc., should be opened, and all unnecessary material should be removed and burned before the chemicals are placed.

6. A door and several windows or other openings should be adjusted so they can be opened from the outside to permit the escape of the gas after fumigation is completed. Where convenient several windows on each floor should have the top sash arranged so they can be lowered by means of a rope from the outside. In this manner ventilation is perfect and the gas soon escapes.

7. A special watchman should be detailed to look after the fumigation and guard the premises while the gas is enclosed and after it is released.

8. In buildings where several rooms or floors are fumigated at the same time, each room or floor should be shut off from the other as much as possible. Where open stairways lead from one floor to another, it will be necessary to cover them temporarily with light boards, over which can be thrown old bags, sacks, blankets, etc. Care should be taken not to blockade the stairway so the operator cannot readily escape when the gas is generated. By closing the doors between the rooms and covering the stairways the gas is kept at a very uniform density in each room for a longer period.

Making the gas.—The chemicals used for making hydrocyanic acid gas are potassium cyanide, sulphuric acid and water. Special directions for combining these chemicals for generating the gas are given in Chapter II. These instructions should be carefully studied and followed specifically, as the process will admit of no guesswork. The cautions cited should be heeded and considered at all times. The acid is first placed in a crock of earthenware or a wooden vessel and the water

poured upon it. The cyanide is afterwards dropped into the liquid, bag and all. The acid soon eats through the paper and a bubbling reaction follows, similar to that produced by placing a piece of red-hot iron in cold water. This lasts a few moments only, or until the acid acts upon the cyanide.

A cloud of white steam is almost instantaneously disseminated throughout the room or enclosure. The odor of this gas is decidedly that of peach pits, and is therefore easily detected. *It is considered one of the most deadly poisons known to chemical science and is certain death to any animal inhaling it.* If a person should breathe his lungs full of it he would not live to know when he took his second breath, if he got it at all. Attention has been called to the dangerous character of the cyanide and this gas in each chapter, and the writer again cautions those who are interested in the subject to handle the material with great care. When so handled there is no danger whatever, and the results are satisfactory in every respect. The effects on animal life given in Chapter IV. should be carefully read in this connection.

Resisting power of insects.—After much experimental work and many practical tests, we have found that the most resistant insects infesting grain and manufactured products are destroyed when the gas is generated at the rate of 0.25 gramme cyanide per cubic foot of space enclosed. The adults of the Mediterranean flour moth, *Ephestia kuehniella*, the Angoumois grain moth, *Sitotroga cerealella*, and the Indian meal moth, *Plodia interpunctella*, are destroyed readily with 0.12 to 0.15 gramme cyanide per cubic foot. The

difference in the resisting powers of various species of insects is so slight we generally recommend for indoor fumigation the use of the 0.25 gramme formula. Under no circumstances should a less amount be used, unless specifically designated by an expert.

Some beetles require the full strength to destroy them in most enclosures. This is particularly true of the bolting-cloth beetle, *Tenebroides mauritanicus*, and its young, a small, flat, whitish, greasy-looking creature, about one-third to one-half inch long, familiar to millers; the flour beetle, *Tribolium confusum*, and its young; the grain weevils, *Calandra granaria* and *C. oryza;* and the American meal worm, *Tenebrio molitor.* In fact, nearly all the beetles commonly found in mills and other enclosures where farinaceous foods are stored or manufactured are not as easily killed with the gas as moths and their young. Bearing these facts in mind, it is, therefore, best to use the gas in accordance with the 0.25 gramme formula.

Estimating chemicals.—The amount of cyanide necessary for any enclosure is determined in terms of grammes per cubic foot of space enclosed. To determine the exact amount of cyanide necessary to fumigate a room, car, ship, or building of any kind, the cubic contents must be accurately computed. As an example, a room 20 x 30 x 10 feet contains 6,000 cubic feet of air space. To estimate the amount of cyanide required for this enclosure, multiply 6,000 by 0.25; thus: $6{,}000 \times 0.25 = 1{,}500$ grammes. To reduce this to ounces, divide by 28.35, as there are 28.35 grammes in an ounce; thus: $1{,}500 \div 28.35 = 53$ ounces, the exact amount of cyanide needed for the enclosure. It

is now easy to determine the amount of acid and water, as a half more acid, liquid measure, than cyanide, and a half more water than acid are used; thus: $53 \div 2 = 26.5$, which, added to 53, equals 79.5 ounces of acid, or practically 5 pounds, liquid measure. Again, 79.5, or practically 80, as we usually discard fractions, divided by 2 equals 40, which added to 80 makes 120 ounces of water.

Therefore, a room 20 x 30 x 10 feet requires 53 ounces, by weight, of cyanide, 80 ounces, liquid measure, sulphuric acid, and 120 ounces, liquid measure, water. The total cost of chemicals will be about $1.25.

Application.—The methods used for generating the gas in large enclosures, such as a mill or other building, is not unlike that illustrated in Fig. 70, Chapter XIV. In our early experimental work it was thought desirable to weigh the cyanide in bags of one pound each, but more recent practical tests have shown that it is more economical and satisfactory to have it weighed out in packages of three pounds each. Where used in this manner the jars or wooden vessels for acid and water should hold two or three gallons each.

If, for example, we had a room in which 18 pounds of cyanide were required, it would be weighed out in six packages of three pounds each. Each package will require a separate generator; therefore, six crocks or wooden vessels will be necessary. They should be arranged at various places in the room. Strings should be arranged so as to hang directly over each vessel, and carried through screw-eyes in

the ceiling or woodwork to the door or stairway leading out of the room, as shown in Fig. 74.

The screw-eyes should be firmly secured, and only strings of good quality used. The bags of cyanide should be thoroughly fastened and suspended over the

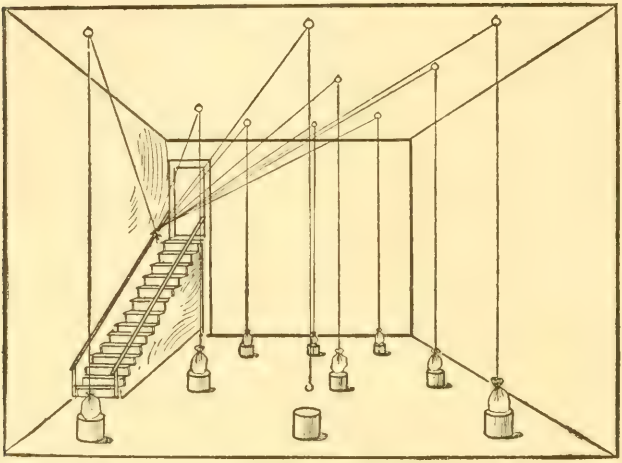

FIG. 74—DIAGRAM SHOWING THE INTERIOR ARRANGEMENT OF AN ENCLOSURE READY FOR FUMIGATION

vessels before the acid and water are placed in them. A small wire hook, as shown in the figure, can be used, but a string tied firmly around the neck of the sack is less trouble and more secure. With each three-pound bag of cyanide use 4½ pounds, liquid measure, sulphuric acid, and 6¾ pounds water.

The operator should begin on the top floor, lower the cyanide into the jars containing the acid and water, quickly close the door or other opening, and

get out. The next story should be handled in the same manner and the room closed. Each floor below, including the basement, is handled the same way. Whenever the gas is generated in a basement, cellar, or in a room where the operator can not get out quickly without climbing a ladder or going up-stairs, great care should be taken. The lines of string leading from the cyanide should be arranged so they can be cut from a point where the operator will have no difficulty in escaping quickly. Under no circumstances should one go into a basement or other enclosure, unite the chemicals, and attempt to escape by climbing a ladder or stair. Such a procedure would be exceedingly hazardous and should be avoided.

Outside doors or other openings in buildings where persons are admitted should be carefully locked or barred, so that no one could possibly enter while the gas is enclosed.

Airing the enclosure.—In buildings where large quantities of grain, manufactured products, or other materials, are stored the gas should be left, where it is convenient to do so, from five to twenty-four hours, or even longer. During this time more or less of the gas will escape, and when the doors or ventilators are opened great care should be taken not to inhale the escaping gas. The building should be left open and allowed to thoroughly air for half an hour or longer before anybody is permitted to enter it. In tight enclosures, such as basements and lower rooms, where free circulation is not available, a longer time may be required to eliminate the gas. In such cases extra precaution should be taken. If there is the slightest

indication of the *peach-pit odor*, the enclosure should not be entered until after it has disappeared.

Residue in vessels.—The material left in the vessels after fumigation should be handled carefully. It is an excellent fertilizer, and can be used for that purpose if composted with earth or other material. Where available, it can best be utilized by throwing it upon a manure pile. Wash quickly in cold water, if by accident the acid is gotten upon the flesh. The chemical composition and value of the residue is given fully in Chapter II.

Cars and ships.—Not infrequently railroad coaches, street-cars and ships become badly infested and overrun with vermin of various sorts. Such enclosures can be readily fumigated with hydrocyanic acid gas by following the directions given herewith. In South Africa some railroad companies have found it expedient to fumigate their passenger coaches to keep them free from bedbugs and other pests. Very often ships are overrun with cockroaches, fleas, bedbugs, etc. The gas can be supplied in such places with perfect success for the total destruction of the vermin. In any case whatever enclosure is to be fumigated the same precautions and methods for handling and generating this gas should be observed.

Dwelling-houses and storerooms.—This gas can also be used with perfect safety in the hands of an expert in dwelling-houses or storerooms infested with the ordinary household pests. In such cases, however, great care should be taken in handling the material, and no person should be allowed to remain in the

house during the process of fumigation. It has recently been applied in a room of the Division of Botany, United States Department of Agriculture, by W. R. Beattie, for the destruction of cockroaches. He recommends the use of the gas at the rate of 0.10 to 0.22 gramme cyanide per cubic foot for the destruction of flies, cockroaches, moths, etc. For fleas and bedbugs the writer has found that a dose varying from 0.20 to 0.22 gramme cyanide per cubic foot is far more desirable.

This method will be found very useful in clearing large hotels, dwelling-houses and other buildings used as summer resorts of undesirable pests. The gas should be applied at a time when the buildings are not occupied. On account of its very rapid diffusion, from three to twenty-four hours will accomplish the desired results. No fumigation for less than three hours is recommended for household pests. Under no circumstances should it be used in a house or other building occupied by other individuals, either above, below, or on either side of the room or apartment fumigated. The gas will in no way injure any article of furniture found in the ordinary household. Care should be taken, however, to remove all edible materials. Water used for drinking should not be left in the room. The gas should not be handled by persons who are not thoroughly familiar with its deadly nature. It is, therefore, not generally recommended for use in houses unless applied by an expert.

Explosive properties.—In all our experiments and recommendations we have kept the amount of potassium cyanide considerably below the danger limit, so

far as combustion is concerned. The gas is non-explosive when used at or below 0.25 gramme potassium cyanide per cubic foot of space enclosed, other conditions being normal. We have asked Dr. H. W. Wiley, Chief of the Bureau of Chemistry, United States Department of Agriculture, for his opinion regarding this matter, and quote the following letter from him:

"Cyanogen gas, or hydrocyanic acid gas, mixed with air or oxygen, forms an explosive mixture, but I should not think that in the proportions you mention, viz., 0.25 gramme of potassium cyanide for each cubic foot of air space, it would produce an atmosphere which would be explosive. Hydrocyanic acid, however, is combustible and could be mixed with air, I presume, so as to form an explosive mixture. I have looked over the authorities, but can find no mention of explosive properties.

"*The danger of hydrocyanic acid, in my opinion, is not from its explosive properties, but from its highly poisonous nature.* Small quantities of hydrocyanic acid gas inhaled are extremely poisonous, and are apt to produce fatal results. *It would be equivalent to instant death for any one to enter a building filled with it.*

"While I do not think there would be danger of an explosion in the proportions you mention (0.25 gramme), I would advise great circumspection in the introduction of a light, unless it be an incandescent electric light, enclosed in an air-tight globe. Such lights should always be used where there is any danger of explosion."

Practical application.—The following testimonials

from a large number of individuals throughout the country, who have used hydrocyanic acid gas in mills, warehouses, elevators and other places, are sufficient to corroborate the statement that it is of very great economic value when used in such places. In quoting these letters all reference to individual and firm names has been omitted purposely. The following is a letter from a Utah milling firm who used this gas recently :

We procured the necessary chemicals and proceeded to carry out your instructions specifically. We believe that we are safe in saying that the experiment was entirely successful, (1) because on leaving the building, after dropping the chemicals into the water and acid, we heard the bubbling described by you, thus proving that action took place between the cyanide and the adulterated acid; (2) when we opened the door of the building, after leaving it closed as directed, two dead pigeons were found (we had placed them in the building purposely), the gas had entirely filled the enclosure, as the two birds were in different places in the rooms; and (3) the best proof that the experiment was successful is the fact that we cannot find any trace of the pests which formerly existed, even though warm weather is here. We wish again to thank you for the interest taken in this matter, as well as the favors extended to us.

Tobacco warehouse.—The writer personally conducted the fumigation of a five-story brick building in Baltimore, September 18, 1900, infested with insects (*Lasioderma serricorne*), injuring leaf tobacco in store, and the method was thoroughly successful. Fifty

pounds of cyanide were used in this building at one time. The four upper stories were fumigated first, and a few days later the basement and first floors. We demonstrated that this gas can be used even in the heart of a solidly built-up city block if properly handled. The building in question is located in the heart of the business center of the city. Every crack about the windows was pasted up with narrow strips of paper. We used string and bags, suspending 3½ pounds of cyanide over each four-gallon jar. We had six jars each on the second and third floors and two each on the fourth and fifth floors. The gas was generated after office hours at 7.30 and the windows were lowered from the outside about 12 o'clock, midnight, the same night. The windows in the fifth story were lowered first, and by opening a door below a draft was created through the elevator shaft carrying the bulk of the gas out above the building. The other windows were opened a few minutes later and the building aired the rest of the night, one man remaining on guard all the time. The results were very gratifying. The pests were thoroughly destroyed, and in addition seven dead rats were found on the basement floor and one on the third floor.

Mills and elevators.—The following is from a Canadian firm: In connection with our use of hydrocyanic acid gas for the extermination of the Mediterranean flour moth, we beg to report the following: The cubic contents of our buildings figure 290,472 cubic feet, for which we used 151 pounds cyanide of potassium, 226 pounds sulphuric acid, and 338 pounds water. We distributed 150 crocks throughout the

buildings, as directed by you, putting about an equal number on each floor, and into each crock we put 1½ pounds sulphuric acid and 2¼ pounds water. We then weighed out 151 pounds of cyanide and put this up in manila bags of 1 pound each; each bag was tied with a string, upon which was left a loop. We placed screw-hooks into different parts of the woodwork, spouts, elevator legs, etc., passed through the hooks stout twine, so arranged that it would come directly over the center of each crock. Just where the string passed over the crock we tied an S-hook, on which we hung the bags of potassium.

The stairways leading from the basement to the top of our mill go up at the side and nearly at the end of the building, one stair directly above the other. At the side and the ends of the mill farthest from the stairway we started six different lines of string, tying one end of each line to the opposite wall, and leading each string to the stairway by a different route over the floor and tying each string tightly to the stairway rail. At the proper moment all the strings on the floor could be cut at the same time, and all the little bags of cyanide would fall immediately into the solution of acid and water.

Each opening at the stairs had been provided with a tight door. The man who cut the strings started at the top floor, worked downward, cutting the strings on each floor as he passed through and closing the door behind him quickly, so that it was impossible for even a whiff of the gas to reach him.

We cut these strings at 8 o'clock Saturday night and placed a man on guard all night The odor

of the gas was quite noticeable twelve feet away from the mill, although every precaution had been taken to close all the cracks by pasting strips of paper around the window-sash and door-frames, and otherwise making the mill as tight as possible. We opened the building at 9 o'clock Monday morning and could not detect more than the faintest odor of the gas. A careful examination showed the floor plentifully sprinkled with moths, flies, spiders, and occasionally a mouse or two. We examined carefully for the grubs or larvæ and found plenty of them dead, and but two or three alive in a mass of flour, but these were not by any means lively. We have watched carefully ever since, over two months, and have seen only an occasional moth. We believe it is impossible to find a moth in our two buildings to-day.

We are delighted with the results of this gas. In our case it has certainly been a decided success. We would say to any one intending to use it they should take every precaution to have the manila bags of good quality. The cyanide of potassium liquidizes after being placed in the bags and exposed to the air. It is apt to drop into the solution by the bag becoming wet and tearing at the bottom before the strings are ready to be cut. In conclusion, we wish to express our hearty appreciation of your painstaking care in the instructions of the use of this gas and also for your personal letters to us with regard to certain particulars.

The following report is from a Western miller: After carefully reading your instructions and closely following them, we fumigated a 150-barrel mill with

marked success. We allowed the gas to remain in the building one night and day. The next morning we found everything had perished, including many mice and weevil. The last day or so we have noticed one or two weevil, probably some that survived by being deeply buried in cracks. We can certainly speak a good word for the remedy, and thank you very much for your instructions, which has aided us in freeing our mill and warehouse from such troublesome pests.

Repeated applications demonstrated that the remedy is one that can be relied upon when properly used. An occasional miller, however, may get a bad lot of chemicals and can not generate the gas properly. One of our Canadian friends wrote recently that he was not very successful in his fumigation, stating that the cyanide did not work in the acid and water. It was apparent to me he had used an old grade of cyanide, about 58 per cent. purity, where he should have had the chemically pure cyanide, guaranteed 98 to 99 per cent. My suspicions were well founded, and a few days later, at my suggestion, he tried the pure cyanide with good results and wrote me as follows August 15:

Your letter of July 22 was duly received and carefully noted. About ten days ago we fumigated again with the hydrocyanic acid gas, and this time with complete success, hardly a bug or grub of any kind being left alive. We see an odd one occasionally, both moth and weevil, and we expect there will be some hatched out from eggs left. We shall fumigate again in another month or so if necessary. The fumigation is so simply done, and so deadly, that we have now no

fear but what we can keep our mill free in the future. We removed all flour, with exception of a few samples, but on these we could discover no taint. Our failure before was owing to inferior cyanide, just as you said, and was our chemist's fault entirely. We again thank you for your advice and information.

Successful application in house and laboratory.—The writer, knowing that Dr. H. J. Webber, of the United States Department of Agriculture, who is in charge of the Laboratory of Plant Breeding, had used hydrocyanic acid gas successfully in a dwelling-house, wrote him for an account of his experience and received the following reply :

"I had one experience in Florida in fumigating a rented house for various household vermin. While such a matter is usually considered strictly a private affair, I have no objection to giving you the following brief note : While living in Florida we moved into a house which was found to be infested with cockroaches and bedbugs. In order to rid the place of these pests it was fumigated with hydrocyanic acid gas, using one ounce of potassium cyanide to each 100 cubic feet of space in the house. The fumigation was started very early in the morning and continued for about six hours, when the windows and doors were opened and the rooms thoroughly ventilated. The house was occupied that night as usual, there being only a slight odor of the cyanide perceptible. The effect of this fumigation was marvelous. I have never, before or since, seen a house so thoroughly cleared of insects."

In the same letter Dr. Webber says they were greatly bothered last summer, in their Washington

laboratory, with cockroaches, the so-called "silver fish," and the Angoumois grain moth. C. P. Hartley, an assistant in the laboratory, had the building fumigated with very excellent results. At the suggestion of Dr. Webber the following statement of facts was furnished by Mr. Hartley:

"During the summer of 1901 one of the laboratories of the United States Department of Agriculture became badly infested with mice and insects of many kinds. It was decided to try the efficacy of hydrocyanic acid gas in ridding the building of these pests. This laboratory had become the abode of cockroaches, beetles, crickets, moths, flies, etc., to some extent because it was connected with greenhouses where these insects abounded, but more especially because of seeds, fruits, and plant specimens that were stored in the various rooms. The entire building, a two-story frame structure of eight rooms, was twice fumigated during the latter part of the summer with such success that the building was free from insects for the rest of the year. The first fumigation was given the latter part of August and freed the building for a week or more, after which time many small roaches and other young insects became noticeable which probably developed from eggs in the building.

"For the first fumigation old stock potassium cyanide from several sources and of various appearances was used, but for the second, ten days later, fresh material was used, and resulted in killing every insect and mouse in the building. This fumigation was started at four o'clock in the evening and the building was kept closed until the next morning, when

it was opened and occupied during the day. The only injurious effects of the gas were on the mice and insects in the building, but the precaution had been taken to remove the unused printing paper and dry plates before the fumigation, although it is not definitely known that they would have been injured by the gas. The morning after the fumigation dead insects were found lying everywhere about the building: flies had dropped from the ceilings and windows, and mice had come from their hiding-places and died.

"For each fumigation one-tenth (0.1) of a gramme of potassium cyanide was used for each cubic foot of space in the building. All the connecting doors were opened. Four stone jars were placed one at each end of the building on the two floors. No exact measurement was made of the strength and quantity of acid, but an attempt was made to use about the same weight of commercial sulphuric acid as of potassium cyanide. The commercial acid was diluted by pouring it into the water which was placed in the jars first. The cyanide was then dropped into the mixture while still hot and the building at once closed for the night."

CHAPTER XVII

GRAINS AND OTHER SEEDS

IN view of the fact that hydrocyanic acid gas is being universally used as a fumigant for the destruction of insects in grain and seeds stored in various enclosures, it became necessary to know how this gas would affect edible and germinating properties of the grain. Conclusive and detailed results were obtained by Dr. Charles O. Townsend, now Pathologist in the U. S. Department of Agriculture. The work was done in connection with the Maryland State Horticultural Department while he was State Pathologist. The methods employed in these experiments consisted simply in placing the seeds to be tested in air-tight chambers and then generating the desired amount of gas. In the first experiments air-tight boxes of several cubic feet capacity, such as are used by nurserymen, were employed. In these various experiments the gas was generated in the same manner as for nursery stock. In later experiments Dr. Townsend used large glass bell-jars. The jars were so arranged that the gas could be generated and kept within them for any length of time with the seeds.

The seeds used were mostly corn, wheat, beans and clover. Occasionally other seeds were used, but those mentioned were carried through all the experiments and fairly represent the common grains and other seeds. Some seeds under certain conditions seem to be more

sensitive to treatment than others, but the behavior in general did not vary much. The strength of the gas used varied from 0.003 of a gramme per cubic foot to 1.45 grammes per cubic foot. In the first experiment Dr. Townsend's object was to determine whether the ordinary strength of gas used in fumigation would be harmful to the seeds. In later experiments he determined the maximum and minimum strength of gas that seeds could resist under varying conditions.

Time is an important factor in this work. Nursery stock must be fumigated 30 to 45 minutes or longer to destroy all insect life, but in the fumigation of buildings in which large bulks of grain are stored, time must be allowed for the gas to penetrate the mass. During this period the grain on the surface is exposed to the influence of the gas from the time it is generated. To determine the shortest and longest time required for grain to respond to the influence of the various strengths of gas under different conditions employed, the exposures varied from one hour to one year. Seeds were also fumigated under varying conditions, some being used while perfectly dry in a dry chamber, while others were used after being soaked in water, and still others were soaked and placed in a moist atmosphere filled with gas. After considering all the facts Dr. Townsend's conclusions are concise, clear and practical.

He found that seeds, whether in the dry or moist condition, are capable of absorbing hydrocyanic acid gas from the surrounding atmosphere, whether the amount of gas in the atmosphere is large or small per cubic foot.

The gas thus absorbed has a marked influence upon the germination of the seeds and upon the subsequent growth of the seedlings. In these experiments it was found that some of the seeds were able to resist for more than three hours the influence of the gas from 0.25 gramme of potassium cyanide per cubic foot, although after three hours 50 per cent. of the seeds were unable to germinate and the other half were held in check for forty-eight hours beyond the usual time of germination. However, the seeds that did germinate produced seedlings that grew at the normal rate. If the grains or seeds are dry, the influence of the gas is far less marked than if they are moist, and the drier they are, the less they are influenced by the gas.

It would seem, therefore, that the gas exerts its influence through the medium of the moisture contained in the seeds and in the seedlings. Even in older plants it is the more succulent parts that are most readily affected by the gas. The seed-coats serve more or less as a protection for the inner seed parts, and as soon as the seedlings escape from the seed-coats they are more seriously affected by the gas, and if the charge is sufficiently strong the seedlings refuse to grow almost as soon as they leave the seed-coats. Dry seeds are sufficiently resistant to the influence of hydrocyanic acid gas to be treated for several weeks with an atmosphere saturated with the gas without destroying their vitality. It would be impossible, however, to preserve even dry seeds indefinitely in any strength of the gas, since it eventually penetrates the dry seeds and impairs and finally destroys the vitality of the seeds. If the seeds are damp they are much more susceptible to

the influence of the gas, and should not remain more than two or three hours in gas of sufficient strength to destroy animal life.

Dry seeds.—Only a few experiments have been performed along this line, but probably a sufficient number to determine the point in question, viz., whether dry seeds treated with hydrocyanic acid gas retain enough of the gas to make them injurious to animal life. Grain was subjected to gas of different strengths, and for longer or shorter periods of time, varying from one to sixty days. Grains thus treated were from time to time fed to mice that had been caught without injury, and placed in glass cages so that they could be observed constantly. The cages were provided with an abundant supply of air and water, and kept at ordinary normal temperature of the laboratory where the mice had been living previous to the beginning of the experiment. Occasionally the mice began eating the grains as soon as they were placed within reach, but, as a rule, several minutes to several hours elapsed between the time the grains were taken from the hydrocyanic acid gas and the time they were eaten by the mice, thus giving time for any gas that remained in contact with the seed or that had penetrated the seed-coat to escape into the amosphere.

In one instance, for example, a mouse was fed one dozen kernels of corn and three dozen grains of wheat that had been for four and one-fourth days in an atmosphere containing gas from one gramme of potassium cyanide per cubic foot. The mouse began eating the grain at once, and at the end of twenty-four hours had eaten the whole of five grains of corn and had

eaten the chit out of five other grains. It had also eaten fourteen grains of wheat and had eaten the chit of eleven others without injury. Several similar experiments were carried through with like results. Hence it seems safe to conclude that dry grains treated for several days with hydrocyanic acid gas of sufficient strength to destroy insect pests that may be in the grain will in no way poison the grain, and it may therefore be used for food without injury.

Damp seeds.—The damp seeds were soaked for twenty-four hours and then treated with gas in the same manner as in the preceding experiments and were kept in the gas for different periods of time varying from several hours to several days in the different experiments. Here, as in the germination experiments, we find that moisture has a decided influence upon the ability of the grains to absorb gas, *i.e.*, after soaking some corn and wheat for twenty-four hours in water and then leaving for forty-eight hours in the gas obtained from one gram of potasium cyanide per cubic foot, a mouse in apparently good health was given twelve grains of corn and thirty-six grains of wheat. The mouse began eating at once and ate the chit out of one kernel of corn and began eating a second kernel when he suddenly became stupid and was unable to walk without staggering. That the mouse was hungry is evidenced by the fact that it began eating as soon as the grain was placed in the cage and from the fact that it had been given but little food on the preceding day for the purpose of having it hungry enough to begin at once on the grain as soon as it was removed from the gas. Although the mouse lived for several

hours, it eventually died apparently from the effects of the small amount of grain eaten, as it did not eat any more of either kernel of grain nor would it eat cheese or any other material placed before it.

In general it was found that if the mice ate the damp grain immediately after taking it from the gas they became stupid and eventunlly died from the effects. If, however, the grain was allowed to remain for a time out of the gas before it was eaten, no ill effects seemed to be produced, although the grain did not seem to return to its normal condition, as it was never eaten readily after it became perfectly dry. When the mice could be induced to eat it, as they were in several instances, it did not seem at all injurious. It may be concluded, therefore, that the fumigation of dry grains with hydrocyanic acid gas does not in any way injure the grain for food purposes. And even if the grain is damp, it will not be made injurious for food, if it is allowed to air for a short time after fumigating before it is prepared for use.

Summary.—In brief, Dr. Towsend has clearly summed up the results of his work in the following paragraphs:

Stored grains and other seeds may be fumigated with hydrocyanic acid gas of required strength and for sufficient time to insure the destruction of insect pests without injury to the germinating quality of the seeds and without rendering them injurious as foods.

Dry grains and other seeds may be fumigated with the usual strength of hydrocyanic acid gas for several days without in any way interfering with the germinating property of the seeds.

Dry grains and other seeds treated for several days with hydrocyanic acid gas of any strength will not be injured for food.

Dry grains and other seeds may be subjected for several months to the influence of hydrocyanic acid gas at the rate of one gramme or less of potassium cyanide per cubic foot without entirely destroying the ability of the seeds to germinate.

Dry grains and other seeds subjected to the influence of hydrocyanic acid gas derived from one gramme of potassium cyanide per cubic foot will lose their germinating ability at the expiration of eight months, while the same seeds subjected to the gas from one-third of a gramme of potassium cyanide per cubic foot will retain their vitality until the expiration of twelve months.

Dry grains and other seeds subjected for from fifteen to sixty days to the influence of hydrocyanic gas from one-third to one gramme of potassium cyanide per cubic foot will hasten germination and accelerate the growth of the resulting seedlings. Although the acceleration continues for several days it does not seem to be of sufficient duration and degree to be of any practical value.

Damp grains and other seeds are much more sensitive to the influence of hydrocyanic acid gas than dry seeds.

Grains and other seeds soaked twenty-four hours or more will not germinate in gas stronger than three-thousandths of a gramme of potassium cyanide per cubic foot, whereas if the seeds are soaked but twelve hours, they are able to germinate in an atmosphere

containing hydrocyanic acid gas from fifty-thousandths of a gramme of potassium cyanide per cubic foot and in much less time than when soaked for twenty-four hours.

Grains and other seeds soaked for twenty-four hours and then left for seven days in an atmosphere of hydrocyanic acid gas will remain inactive while in the gas and from seven to twelve days after removal, but will eventually germinate to some extent if the strength of gas used does not exceed fifty-thousandths of a gramme of potassium cyanide per cubic foot, *i.e.*, hydrocyanic acid gas is capable of holding seeds in an inactive state for two weeks or longer without destroying their vitality, even when the conditions are otherwise favorable for germination.

Damp grains and other seeds treated with hydrocyanic acid gas of any strength even for short periods of time should not be used for food until several hours after removing from the gas. The effect of the gas eventually passes off and the grain may be eaten with safety, although long exposure to the gas seems to render it unpalatable.

In the first experiments conducted by the writer, where grain and manufactured products were stored, the gas was generated at the rate of 0.10 to 0.12 gramme per cubic foot. Very satisfactory results were secured, but further experiments showed that it was better to use from 0.20 to 0.25 gramme per cubic foot of space enclosed. It was found that a greater volume of gas remained in the building for a longer time where larger doses were used. At the same time no deleterious effects were observed either in the manu-

factured products or the grain in storage. Repeated applications of this gas in mills, elevators, and other enclosures with the 0.25 gramme formula has proven that this is one of the most effective and satisfactory remedies for the destruction of insects and vermin in such places now known.

CHAPTER XVIII

DIFFUSION OF HYDROCYANIC ACID VAPOR

IN a recent report (twelfth) of the Delaware Agricultural Experiment Station, Prof. Charles L. Penny gives the results of a careful series of experiments to determine the diffusion of hydrocyanic acid vapor in an enclosed space, from which the following facts are abstracted or quoted: In all the diffusion experiments, in both small boxes and large rooms, a uniform charge of chemicals was used. For each cubic foot of space to be filled with 0.2 gramme potassium cyanide, 0.45 c. c. water, and 0.3 c. c. of 91 per cent. sulphuric acid.

In the box experiments the acid was allowed to run into the cyanide previously dissolved in water. In the room experiments the water and acid were poured together in a two-gallon earthen vessel, into which the cyanide was dropped. As the potassium cyanide was on the average of 96.7 per cent. purity, containing 40.14 per cent. hydrocyanic acid, it would have furnished 0.08028 gramme of that acid per cubic foot if all had been liberated. Professor Penny found, as he expected, that a certain amount of hydrocyanic acid always remained in solution in the generating liquid, depending on the temperature and the time of exposure of the latter. In the case of the box experiments this residual hydrocyanic acid varied from 2 to 8 per cent. of the whole amount originally present, and

after standing over night it was as little as 0.66 per cent., averaging 4.71 per cent.; the particular amount was determined for each experiment and was deducted to determine the amount of actually liberated or available hydrocyanic acid vapor.

In the case of the room experiments the average residual hydrocyanic acid was found to be 4.97 per cent. of the whole amount; this was deducted in each case to determine the liberated or available vapor. Thus, at the temperature at which the experiments were made, both with large and small quantities of reagents, the proportion of acid and water used gave about 95 per cent. of available vapor. This liberated or available vapor on an average 0.07623 gramme per cubic foot of space, called by Professor Penny the "*HCN*," was taken as the basis of calculation to determine the ratio of diffusion; in other words, that amount found in a cubic foot would be called a diffusion of 100 per cent.

Quite as important as the average percentage of diffusion, Professor Penny shows, is the average percentage of fluctuation. In such work absolute uniformity of conditions with the facilities available is not attainable; hence repeated trials with conditions apparently the same often give different results, sometimes widely different. As perfectly air-tight walls, both of boxes and of the room, are difficult to secure, there are varying conditions that make no two trials exactly alike. Such discrepancies, although they cannot be foreseen, may be explained by variations in the force and direction of the wind, varying amounts of humidity and the host of minor conditions that are never quite

the same, but yet influence the result. Hence, in addition to the average diffusion, the fluctuation in percentage between repeated trials is given. This indicates the degree of constancy in the work.

It might be supposed, says the author, as pure hydrocyanic acid is a liquid that boils at 80° F., and inasmuch as most practical applications of the acid are made below that temperature, that ordinarily but a small portion of the acid would vaporize, and that this portion would diminish rapidly with a falling temperature. Such, however, is not the case. The proportion of the acid used in Professor Penny's experiments, if it were all liberated, would amount in weight and also in volume to only one five-hundredth part of the air. As the vapor pressure of the acid is half an atmosphere at 40° F., it is clear that even in this low temperature many times as much acid as could ever be used (in fact, over two hundred times as much) would still remain in the state of vapor. Hence the condensation of the minute trace of hydrocyanic acid that is ever used in practice would be impossible at any natural temperature whatever. The "surface condensation," referred to later by Professor Penny, is the solution of the acid in the film of condensed moisture adherent to walls and other surfaces.

The results.—The results summed up below were obtained by Professor Penny with a box of sixty cubic feet capacity, of which the horizontal dimensions were 8 feet by 3 feet and the vertical depth 2½ feet. The box had double wooden walls, with paper between them, and made as nearly air-tight as possible. The generator and the point at which the sample was

taken, or the "intake," were in one case at the same end of the box, in the other case at opposite ends. The "diffusion time" was the time elapsed between the liberation of the vapor and the taking of the sample.

"It appears," says Professor Penny, "from the results obtained that immediately after the generation of the hydrocyanic acid, as would be expected, there is an excess of it around the generator, that this excess disappears within two minutes, leaving but one-third the normal quantity at that point, and that at the opposite end there is a still greater excess, viz., two and one-half times the normal amount; that this latter excess in turn rapidly falls and the vapor around the generator again increases in amount, so that there is a tendency toward equilibrium, though considerably over twenty minutes would be required to approximate perfect equilibrium. Hence, for the duration of a practical trial by far the greater amount of vapor would be in the end of the box farthest from the generator.

"The fluctuations between repeated trials under similar circumstances are relatively slight; that is, uniformity is the rule. What is found true in one instance is, with due regard to the general character of the work which precludes extreme accuracy, substantially true in similar instances. This may be attributable in part to the double walled and paper-lined box, which reduced the influence of air currents to a minimum."

Diffusion in box.—"The following results in the second experiment were obtained with a box of 29

cubic feet capacity, of which the horizontal dimensions were $13\frac{1}{2}$ feet by $1\frac{1}{2}$ feet and the vertical $1\frac{1}{2}$ feet. The experiments covered five different cases, and it appears first that there is less uniformity than with the box of 60 cubic feet. This may be due, and probably is in part, to the structure of the two boxes, the former having rawhide roofing paper sides and the latter double sides with paper lining. Hence in the case of the box under discussion outside disturbing influences may have been felt to a greater degree.

"With the intake at the same end of the box as the generator, after three minutes' diffusion time there appeared in a single instance a deficit of acid vapor as compared with the normal, in two other instances a considerable excess. The extreme fluctuations found show forcibly the inconstancy of spontaneous diffusion, especially with this arrangement and after a short interval of time. With the generator at the middle of the box and the intake at the end there is greater uniformity and after ten minutes a considerable deficit, which deficit remains practically the same for a half hour; the amount of vapor then gradually diminishes, doubtless through leakage. It appears then that of these two arrangements, viz., the generator in one case at the end of the box and again in the middle, the latter gives more uniform results and also a more even distribution of the acid vapor. This is, perhaps, what would be expected, but it must be noted that even in the latter case the quantity of vapor in one instance is double what it is in two other instances.

"*In summary*, then, be it noted of these cases of spontaneous diffusion that within a half hour of diffu-

sion time the amount of hydrocyanic acid vapor at a given point may be as little as 23 per cent. of the normal and as high as 272 per cent., or, with the same quantity of reagents per cubic foot and in the same box, at one point there may be twelve times as much acid vapor as at another. Of course this inequality would not continue long, but it does exist in certain cases for a time. Hence it must be apparent, if we rely on spontaneous diffusion, that the amount of cyanide used per cubic foot is no guarantee on the one hand of sufficient acid vapor to do the work, nor, on the other, of too little to injure plants."

Mechanical mixer.—In these tests a mechanical mixer was used in the box of twenty-nine cubic feet capacity. This device consisted of a fan on a horizontal axis which passed through the sides of the box and was turned by means of a crank from the outside. The results showed a remarkable uniformity for work of this general character, varying from 68 per cent. to 74 per cent. of the normal. The average is 72 per cent., and this may be taken as the true measure of efficiency under these conditions, *i.e.*, with a similar size and proportion of box and equal loss from leakage. As about 5 per cent. of the total hydrocyanic acid remains in solution in the generator, and of the 95 per cent. evolved 72 per cent. is uniformly diffused, it would follow that about 68 per cent. of the total hydrocyanic acid gas originally present in the cyanide, or approximately two-thirds, becomes efficient by uniform diffusion throughout the box. Of the remaining 32 per cent., aside from the 5 per cent. left in the generator, the balance, 27 per cent., is to be accounted for by

leakage and by surface condensation on the walls of the box, or rather by solution in the film of moisture adherent to the walls.

Effect of moisture on foliage.—"Experiments were designed to show the effect of moisture adherent to foliage. A quantity of maple and cherry leaves were held under a hydrant, then shaken to remove the excess of water and placed in the diffusion box. The amount of adherent water was about two and three-quarter pounds. In each trial a fresh lot of leaves was used, and a mechanical mixer or fan was used to complete the diffusion. Two trials showed an average of 54 per cent. as compared with 72 per cent. obtained without the wet leaves, or, with the wet leaves, just three-fourths as much acid vapor is diffused through the atmosphere of the box as without them. This is significant as indicating the effect of wet foliage. The amount of acid vapor available for killing insects is diminished and the amount acting directly on the plants is increased." Thus the necessity of having plants either in the nursery or orchard as dry as possible.

Absorbent effect of fresh earth.—"In this experiment the bottom of the 29-cubic foot box was removed and the box was placed over fresh soil; the soil was thoroughly packed or tamped around the edges. The surface soil thus exposed was 1½ x 13½ feet, or about 20 square feet. The mechanical mixer was used, as noted above. The two trials, with closely concordant results, show an average of 44.5 per cent. of the normal amount of acid vapor as compared with 72 per cent. of

soil. Hence, in a box resting on soil, about 62 per cent. as much acid vapor is available as in a closed box. It would seem necessary, then, in work of this sort over soil to use nearly twice as much cyanide and other reagents as in a closed box."

Diffusion in large room.—"Experiments were made in a rectangular room of which the horizontal dimensions were 20 feet 9 inches by 19 feet 1 inch, and the height 10 feet 11 inches, and which included 4,332 cubic feet. The walls and ceiling were plastered and the floor was of boards; there were four windows and three doors. The crevices were stopped as far as possible, but necessarily the room was far from airtight. Samples of air were taken simultaneously from three different points within the room. The position of two of these points and also of the generator was changed several times in order to study the diffusion in different places. The generator was a glazed stoneware vessel 8 inches in diameter and 15 inches high. The charge of reagents in the case of the room-experiments was the same per cubic foot as in the case of the box-experiments, in the former amounting to 866.5 grammes cyanide, 1,300 c. c. of concentrated sulfuric acid, and 1,950 c. c. of water. The water was poured into the generator, the acid was then poured into the water, and immediately thereafter the cyanide, wrapped in paper, was dropped by means of a string, into the acid mixture."

General results.—"After ten minutes of diffusion time, with the generator in one corner on the floor, the amount of vapor in the center of the room at the ceiling

was about normal, with a trifling excess. On the floor by the side of the generator there was none at all, or only a mere trace. On the floor diagonally opposite to the generator it averages, with rather wide fluctuations, 73 per cent. of the normal. After 20 minutes the center at the ceiling showed a trifling loss, the point on the floor next to the generator showed 27 per cent. of the normal, and the point on the floor in the opposite corner showed 94 per cent. After 30 minutes these figures were not greatly changed for the first and the last, while for the second point, that next to the generator, the vapor is 51 per cent. of the normal, nearly double its amount after 20 minutes. After an hour the diffusion is practically complete, the amount of vapor at the three points being 52, 44 and 44 per cent. of the normal, while after four hours and a half it is 25, 24 and 21 per cent., respectively.

"It is apparent that there is a rapid loss in the total amount of acid vapor from the room as a whole. This loss cannot be easily estimated until there is practically complete diffusion, as the average of the three points would not necessarily, nor even probably, give the average for the whole room. It would seem, then, after one hour there is a trifle less than one-half of the normal amount of acid vapor in the room, and after four and one-half hours a trifle less than one-quarter. The rate of loss is probably greater through a plastered wall than through one of boards, and it would doubtless require a special air-tight construction of a room to reduce this rate very considerably. Hence, the constant loss must be borne in mind in considering the completeness of the diffusion.

"It is clear from the results that the acid vapor rises from the generator vertically, follows the ceiling, descends on the opposite side of the room and completes the circuit by returning to the generator. Thus the point immediately at the side of the generator is the last to receive any vapor, while the opposite point on the floor quickly receives almost its normal amount. This is what might be expected from the shape of the generator, an open jar, 15 inches high and 8 inches in diameter, which has the effect of projecting the charge of vapor directly upward; and, furthermore, while the density of hydrocyanic acid vapor, a very little less than that of air, is not small enough to cause it to rise rapidly, yet its expansion by the heat of the reaction is considerable. Hence the tendency of the acid vapor to ascend is, for several reasons, the natural thing to expect, and to secure rapid diffusion a counteracting cause must be set to work. At the moment of generation the vapor, or, rather, the accompanying condensed steam, may be actually seen to take the course that has been described, though naturally but for a minute or two.

"When the generator is moved to the center of the floor, the intake remaining in the same place, after ten minutes there is found 75 and 88 per cent. in the two corners and 123 per cent. in the center of the ceiling. This is in general agreement with what has already been noted, as in this case the two corners are arranged alike in reference to the generator, and, as before, the greater part of the acid vapor is at the ceiling.

"Where the generator is in the corner of the room and the three intakes are in a vertical line in the

center of the room, one near the ceiling, one near the floor, and one midway between, after twenty minutes practically the same amount of vapor on an average is found at the ceiling and at the middle point, whereas the space near the floor shows about one-third as much as the other two.

"Where the generator is covered with a box that extends on all sides to the floor, the effect is to throw the vapor down to the floor. The results show a greater amount there than in the preceding arrangement. This device is quite inadequate to secure an even distribution of vapor.

"In this test the generator was placed two feet from a side wall at the middle point, and provided with a horizontal distributing tube. The intakes were in a vertical line in the center of the room. The effect of this simple arrangement was surprising. After ten minutes there was practically a uniform distribution of acid vapor, at least in so far as the three points of sampling may be taken as typical, and they seem to be fairly representative. After twenty minutes there was found to be but a slight change, well within the limits of fluctuation in work of this sort. This simple device, designed by Professor Sanderson, is shown in Chapter XII. The acid vapor is distributed immediately with surprising uniformity. Thus has been solved perfectly the difficulty of securing an even and speedy diffusion, and that, too, in a very simple and practicable way.

"These results may be taken as showing fairly well how much of the hydrocyanic acid can be accounted for, and that is 93 per cent. of what is actually evolved, or about 88 per cent. of the total amount contained in

the cyanide. Thus, of the total amount of hydrocyanic acid about 5 per cent. remains in the generator, 88 per cent. is diffused, and 7 per cent. must be charged to leakage or surface condensation on the walls of the room. In the experiments with the box it was estimated that only 68 per cent. of the total hydrocyanic vapor is actually efficient, the remainder being lost in the ways suggested. This greater loss with the smaller box is just what we should expect, for the relative amount of wall surface as compared with the cubic contents is much greater."

CHAPTER XIX

RECENT WORK WITH HYDROCYANIC ACID GAS

S*UCCESSFUL APPLICATION IN ENGLAND.*—The black currant bud-mite and the mealy bug are among the most dangerous and elusive enemies of the greenhouse and garden in England. So severe have been the losses by the former that the currant industry is in a critical state. One grower is reported as having said recently that his crop had fallen from £1,400 a year to practically nothing on account of the mite. The latter pest is found generally in the vinery. The application of sprays and washes have not been successful in keeping either pest in check.

In a recent paper by H. H. Cousins, in the Journal of the Agricultural College, at Wye, Kent (Vol. XXV.), he reports successful results where hydrocyanic acid gas was used. Speaking of his experiments, he says the spread of the black currant bud-mite is clearly due in the first place to the propagation by cuttings from infested stock. Buds of apparently normal dimensions frequently contain a few mites capable of indefinite increase. In the case of the Baldwin currant it is most difficult to find a shoot free from mites, even when the buds appear quite healthy. Diseased stock undoubtedly spreads the infection by the mechanical distribution of the mites on the clothes

of the men engaged in hoeing, or through the agency of the wind or of birds.

Preliminary experiments indicate that at least forty minutes' exposure to the cyanide fumes was necessary to ensure the complete destruction of the mites. Shorter periods were apparently successful at a first inspection, but a further examination showed that many individuals recovered after twenty-four hours. Doses of cyanide varying from 0.05 gramme to 0.4 gramme per cubic foot were tested. A minimum of 0.2 gramme per cubic foot was satisfactory. A stronger dose than 0.3 is not desirable.

Cuttings and young bushes.—About 2,000 diseased bushes intended for planting were treated January 3d as follows: They were tied in bundles and placed in a heap on the ground. Four hurdles were arranged as a support, and the whole covered with a waterproof cloth. A small vessel was placed on the ground in the center of the heap of bushes. One hundred cubic centimeters of water (about 4 ounces) were added, followed by an equal volume of strong sulphuric acid. Thirty-six grammes (about 1¼ ounces) of commercial 98 per cent. potassium cyanide was wrapped in thin blotting-paper and dropped cautiously into the vessel of acid and water. The hand was at once withdrawn and the canvas carefully pressed down all round with lengths of timber. After one hour the cloth was removed and the operation was complete.

Mr. Theobald conducted a systematic microscopic analysis of the treated buds, and established the fact that this treatment had destroyed all the mites. The bushes were planted out in disease-free soil and were

under constant inspection. A fortnight later a second batch of young bushes was similarly treated and with identically good results.

The cost of chemicals is only about a penny per thousand bushes and the labor involved trifling. All cuttings should be fumigated before being set. Black currants so quickly come to a good bearing size that it would be well to grub a badly infested plantation and start afresh with fumigated young stock.

To the above report A. D. Hall, the principal of the college, adds the following: "I am not by any means disposed at present to definitely recommend the hydrocyanic process other than by way of experiment, and until we have seen more results I should prefer to say nothing. If the process recommended be carried out in the winter, when the temperature is low and the bushes in a dormant state, no injury whatever is done to the plants. The real difficulty lies in the eggs of the mite ; it seems to be always laying eggs, except perhaps in the very coldest weather ; and though we are now sure the adult mite is killed by the treatment we are still doubtful about the eggs. The treatment of large bushes *in situ* has failed on the whole."

Mealy bug in vineries and conservatories.—Through the kindness of Colonel Ready, of Goudhurst, and Mr. Hammond, of Ramsgate, Mr. Cousins was enabled to try the effect of cyanide fumigation under a variety of conditions. Three vineries, *A*, *B*, and *C*, were twice treated, as was also a large conservatory. In each case the attack of the mealy bug was severe.

Vinery A.—The capacity of this house was 3,430 cubic feet. It contained an early variety and was

treated when vines were in full bloom with the following: Cyanide, 18 ounces; acid, 27 fluid ounces; 1 quart of water. The temperature was 60° F. Time of exposure was half an hour. The work was done after sunset. The mealy bug was destroyed, foliage unhurt, but three-quarters of the bloom was injured. A few mealy bugs appeared at the close of the season, after the grapes had been gathered. A second fumigation was therefore decided upon and the results were satisfactory.

Vinery B had a capacity of 3,825 cubic feet and contained a late variety. It was treated before vines bloomed with the following dose: Cyanide, 27 ounces; acid, 40 ounces; water, 60 ounces. The application was made after sunset and exposed three hours at a temperature 60° F. The mealy bug was destroyed and there was no injury to vines. A few insects appeared in the autumn and a second fumigation was given, with the same success as in the previous case.

Vinery C had a capacity of 1,990 cubit feet and was planted with an early variety. It was treated when the grapes were the size of peas with the following chemicals: Cyanide, 6 ounces; acid, 9 ounces; water, 15 ounces. The temperature was 65° F.; weather very sultry at the time. Time of exposure was forty minutes and application was made at 3 P.M. The grapes were browned and killed, while the foliage was uninjured. The mealy bug was destroyed. The vinery was kept on the cool side, plenty of air given, and splendid growth and promise of fruit for next year was obtained. A few mealy bugs appeared in October. Fumigation was repeated. All

the bugs were destroyed. The season had so far advanced, however, that the eggs were to be found on the shoots. Painting the rods with the winter alkali wash in the spring and a fumigation before the bloom appears to have been decided upon.

A conservatory of 300 cubic feet, containing mixed flowers and ornamental plants and ferns, etc., infested with aphis and mealy bug was fumigated after sunset with cyanide, 8 ounces; acid, 12 ounces; water, 20 ounces. The temperature was 50° F. Time of exposure was three-quarters of an hour, with complete success. There was no injury to maidenhair fern or any of the plants under treatment. The cost did not exceed 1 shilling.

A greenhouse of 2,000 cubic feet, containing chrysanthemums in full bloom severely infested with green-fly, was treated one hour before sunset with cyanide, 3½ ounces (0.05 gramme per cubic foot); acid, 5 ounces; water, 9 ounces. The temperature was 52° F. and the time of exposure was 25 minutes. Every aphis was killed, also slugs, flies, wasps and butterflies. A toad was uninjured. Not a petal or leaf was hurt.

Conclusions.—Mr. Cousins is of the opinion that these experiments should encourage practical men to give cyanide fumigation a thorough trial for such pests as are beyond ordinary treatment. For greenhouse work he recommends the following: If the house be under 10,000 cubic feet one vessel will suffice; if over, provide a vessel for each 10,000 cubic feet. Arrange the ventilators so that they can be opened

from without. The foliage of the plants should be dry. A temperature not exceeding 60° F. and preferably of 50° F. is desirable. Above 60° F. there is risk of injury to the foliage.

For mealy bug, 3 ounces cyanide, 5 ounces acid, 15 ounces water per 1,000 cubic feet, either before the vines bloom, or when grapes are coloring, or after the crop has been gathered. At either of these stages no harm results to either foliage or fruit. Avoid fumigation when the vines are in bloom, or before the grapes have commenced to ripen.

For ordinary greenhouse pests, such as aphis, dolphin, whitefly, slugs, woodlice, red-spider, and caterpillars, a dose not exceeding 1¾ to 2 ounces cyanide, 4 ounces acid, 7 ounces water per 1,000 cubic feet, has been found satisfactory in England. For a detailed account of greenhouse fumigation see Chapter XIV.

Use in New South Wales.—In the center of the citrus-growing belt of New South Wales, W. J. Allen, an expert of the government, has conducted some very satisfactory experiments with hydrocyanic acid gas in cooperation with the Glenorie Progress Association. Various sprays were tried at the same time and compared with the gas treatment. In his report of the practical tests, printed in Vol. XII. of the *Agricultural Gazette* of New South Wales (see also *Agricultural Gazette* for August, 1899, and July, 1900), Mr. Allen says:

The fumigation of the trees with hydrocyanic acid gas gave the best results of all. This was conceded

by all growers who followed up the experiments. The cost of treatment was the same as that of the blue oil emulsion and slightly in excess of the resin work.

FIG. 75—FUMIGATING IN G. TURNER'S ORCHARD AT GLENORIE, NEW SOUTH WALES. (AFTER ALLEN)

The fumigated trees made a better growth than those in the same orchard not treated.

Several prominent growers requested Mr. Allen to fumigate one or two badly infested trees in their orchards, and, by the way of experiment, wished him to give the trees an extra charge. They wanted to make sure of killing the scale and see also the effect on

FUMIGATED FIG. 76 NOT FUMIGATED

These two orange trees, side by side in a New South Wales orchard, were equally infested with scale. One was fumigated, while the other received no treatment. The pictures were taken four months later. Note the difference. (After Allen)

the tree. The trees were treated in the hottest part of the day. This, added to the overcharge of cyanide, caused many of the leaves to fall; yet it had little or no effect on the fruit, and all the scales were killed, Two-thirds of the dose would have been quite sufficient to have cleaned the trees.

Lemons and mandarins stand the fumigation much better than the orange. Taking two trees of equal size and treating them with the same charge, while the mandarin would not show any ill effect, the orange tree would lose a few of its leaves. Mr. Allen, therefore, recommends always treating the latter at night or on cool and dull days. The night treatment appears to be the best, as a charge which would in the daytime remove leaves, and, perhaps, burn the tender parts of the twigs, would have no detrimental effect where the work was performed at night. He thinks that lemons and mandarins can be treated with very good results during the daytime, except on very hot days.

When Mr. Allen first commenced his fumigating experiments in New South Wales the price of tents was so high as to make it appear to growers that this method of treating trees was quite out of the reach of the average fruit-grower ; but several large growers, rather than pay a high price for material, bought strong calico and sail-cloth, and made tents from these materials, and these, after a fair trial, have stood the test quite as well as the more expensive duck tents, and cost only about one-quarter as much.

The cost of material for tents made of sail-cloth 6 feet wide, estimated by Mr. Allen, is as follows for the

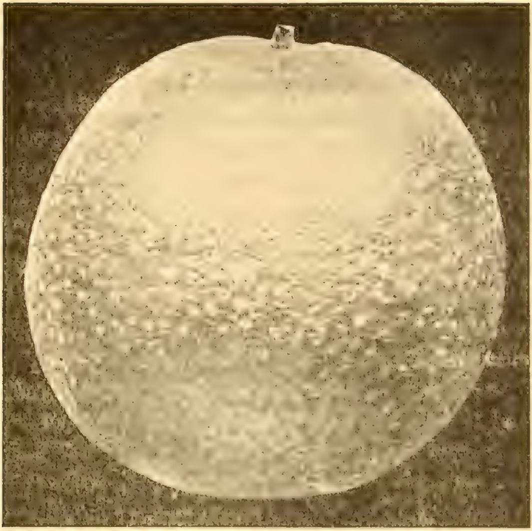

FIG. 77—AVERAGE SPECIMEN OF FRUIT FROM A FUMIGATED TREE IN NEW SOUTH WALES ORCHARD. (AFTER ALLEN)

FIG. 78—AVERAGE SPECIMEN OF FRUIT FROM A TREE IN SAME ORCHARD AS ABOVE, NOT FUMIGATED (AFTER ALLEN)

different sizes: Tents 15 feet high, 24 feet in circumference, require 16 yards of sail-cloth 6 feet wide, which, at 1*s.* 3*d.* per yard, will cost £1; tents 18 feet high, 36 feet in circumference, require 30 yards of sail-cloth 6 feet wide, which, at 1*s.* 3*d.* per yard, will cost £1 17*s.* 6*d.*

He says these are two of the most useful large-sized tents for general use. The former is quite large enough to cover trees 10 feet high and 8 feet in diameter, while the latter is large enough to cover trees 13 feet high and 10 to 12 feet in diameter. If larger trees are to be fumigated it is best to have octagonal sheets, sizes either 41 x 41 or 50 x 50. A sheet is always much easier to put over the tree than a tent where large trees are being handled. The price of making the tents is not given, as any person having a sewing-machine can sew them together. To make the former tent the material is cut in two. Find the center of each length, and from this point measure back 3 feet on opposite sides, draw a line diagonally across from one point to the other, and cut as marked. After cutting the two pieces can be sewn together. For the large-sized tent, the 30 yards must be cut in three pieces of 10 yards each, which should be cut again in an exactly similar manner to the smaller-sized tent and sewn together. Great care must always be taken to keep the tents perfectly air-tight.

Good results.—The outcome was very gratifying, and Mr. Allen says: "I feel quite safe in saying that by the autumn of 1901 there will be over a thousand tents in use in New South Wales, with the result that there will be more clean and better fruit for export

and home consumption, and more healthy and vigorous trees found in our fruit-growing districts. In most cases the fumigation was successful wherever experiments were conducted, and there can be no better proof than that the growers are adopting this method of destroying scales more and more as they become acquainted with its advantages."

Various materials have been used for making tents. Mr. Allen thinks that tents made of sail-cloth will be found durable and economical. We reproduce herewith the table, compiled by Mr. Allen, for the various amounts of chemicals to be used in orchards in New South Wales.

ALLEN'S FUMIGATION TABLE FOR NEW SOUTH WALES ORCHARDS

Diameter	*Hight*	*Capacity*	*Cyanide*	*S. Acid*	*Water*	*Diameter*	*Hight*	*Capacity*	*Cyanide*	*S. Acid*	*Water*
			oz.	*oz.*	*oz.*				*oz.*	*oz.*	*oz.*
4	4	43	1/3	1/3	1 1/4	11	8	653	3 1/4	3 1/4	9
4	5	54	1/3	1/3	1 1/4	11	9	735	3 3/4	3 3/4	10
4	6	65	1/3	1/3	1 1/4	11	10	817	4	4	12
5	5	85	1/2	1/2	1 1/2	11	11	898	4 1/2	4 1/2	13
5	6	101	1/2	1/2	1 1/2	11	12	980	4 3/4	4 3/4	14
5	7	118	1/2	1/2	1 1/2	11	13	1,062	5 1/4	5 1/4	15
6	6	146	3/4	3/4	2	11	14	1,144	5 3/4	5 3/4	17
6	7	170	1	1	2 1/2	12	8	778	3 3/4	3 3/4	10
6	8	195	1	1	2 1/2	12	9	875	4 1/3	4 1/3	13
7	7	232	1 1/4	1 1/4	3	12	10	972	4 3/4	4 3/4	14
7	8	265	1 1/4	1 1/4	3	12	11	1,069	5 1/4	5 1/4	15
7	9	298	1 1/2	1 1/2	4	12	12	1,168	5 3/4	5 3/4	17
8	8	346	1 3/4	1 3/4	5	12	13	1,264	6	6	18
8	9	389	1 3/4	1 3/4	5	12	14	1,361	6 3/4	6 3/4	19
8	10	432	2 1/8	2 1/8	6	12	15	1,458	7 1/4	7 1/4	21
9	8	437	2 1/8	2 1/8	6	13	8	947	4 1/2	4 1/2	13
9	9	492	2 1/2	2 1/2	7	13	9	1,026	5	5	15
9	10	547	2 3/4	2 3/4	9	13	10	1,141	5 3/4	5 3/4	17
9	11	601	3	3	9	13	11	1,255	6 1/4	6 1/4	18
10	8	540	2 3/4	2 3/4	9	13	12	1,369	6 3/4	6 3/4	19
10	9	608	3	3	9	13	13	1,481	7 1/3	7 1/3	21
10	10	675	3 1/3	3 1/3	9	13	14	1,597	8	8	24
10	11	743	3 3/4	3 3/4	10	13	15	1,711	8 1/2	8 1/2	24
10	12	810	4	4	12	14	8	1,050	5 1/4	5 1/4	15

ALLEN'S FUMIGATION TABLE FOR NEW SOUTH WALES ORCHARDS.—*Continued*

Diameter	*Hight*	*Capacity*	*Cyanide*	*S. Acid*	*Water*	*Diameter*	*Hight*	*Capacity*	*Cyanide*	*S. Acid*	*Water*
			oz.	*oz.*	*oz.*				*oz.*	*oz.*	*oz.*
14	9	1,191	6	6	18	18	17	3,718	18½	18½	55
14	10	1,323	6½	6½	19	18	18	3,937	19½	19½	58
14	11	1,455	7¼	7¼	21	18	19	4,156	20½	20½	61
14	12	1,587	7¾	7¾	22	18	20	4,374	21¾	21¾	65
14	13	1,720	8½	8½	24	18	21	4,593	22¾	22¾	68
14	14	1,852	9¼	9¼	27	18	22	4,812	24	24	72
14	15	1,984	9¾	9¾	28	18	23	5,030	25	25	75
14	16	2,116	10½	10½	30	18	24	5,249	26	26	78
15	8	1,215	6	6	18	19	13	3,168	15½	15½	46
15	9	1,367	6¾	6¾	19	19	14	3,412	17	17	51
15	10	1,519	7½	7½	22	19	15	3,656	18	18	54
15	11	1,671	8¼	8¼	24	19	16	3,899	19¼	19¼	57
15	12	1,823	9	9	27	19	17	4,143	20½	20½	60
15	13	1,975	9¾	9¾	27	19	18	4,387	21½	21½	64
15	14	2,127	10½	10½	31	19	19	4,630	23	23	69
15	15	2,279	11¼	11¼	33	19	20	4,874	24	24	72
15	16	2,430	12	12	36	19	21	5,118	25	25	75
15	17	2,582	12¾	12¾	37	19	22	5,362	26½	26½	78
15	18	2,734	13½	13½	40	19	23	5,605	28	28	84
15	19	2,886	14¼	14¼	42	19	24	5,849	29	29	87
15	20	3,038	15	15	45	20	13	3,512	17½	17½	52
16	10	1,728	8½	8½	24	20	14	3,782	18½	18½	55
16	11	1,901	9½	9½	28	20	15	4,053	20	20	60
16	12	2,074	10¼	10¼	30	20	16	4,323	21½	21½	63
16	13	2,247	11	11	33	20	17	4,593	22¾	22¾	67
16	14	2,420	12	12	36	20	18	4,863	24	24	72
16	15	2,492	12½	12½	37	20	19	5,133	25½	25½	75
16	16	2,765	13¾	13¾	40	20	20	5,404	27	27	81
16	17	2,938	14½	14½	43	20	21	5,674	28	28	84
16	18	3,111	15½	15½	46	20	22	5,944	29½	29½	88
16	19	3,284	16¼	16¼	48	20	23	6,214	31	31	93
16	20	3,456	17¼	17¼	51	20	24	6,484	32	32	96
16	21	3,629	18	18	54	21	14	4,168	20½	20½	60
16	22	3,802	19	19	57	21	15	4,466	22	22	66
17	12	2,341	11½	11½	34	21	16	4,763	23½	23½	69
17	13	2,536	12½	12½	37	21	17	5,061	25	25	75
17	14	2,731	13½	13½	40	21	18	5,359	26½	26½	78
17	15	2,926	14½	14½	43	21	19	5,657	28	28	84
17	16	3,122	15½	15½	46	21	20	5,954	29½	29½	88
17	17	3,317	16½	16½	49	21	21	6,252	31	31	93
17	18	3,512	17½	17½	52	21	22	6,550	32½	32½	97
17	19	3,707	18½	18½	55	21	23	6,847	34	34	102
17	20	3,901	19½	19½	58	21	24	7,145	35½	35½	106
17	21	4,096	20¼	20¼	60	21	25	7,443	37	37	111
17	22	4,291	21¼	21¼	63	22	15	4,901	24½	24½	73
18	12	2,625	13	13	39	22	16	5,228	26	26	78
18	13	2,843	14	14	42	22	17	5,555	27½	27½	82
18	14	3,062	15¼	15¼	45	22	18	5,881	29	29	87
18	15	3,281	16¼	16¼	48	22	19	6,208	31	31	93
18	16	3,500	17½	17½	52	22	20	6,535	32½	32½	97

ALLEN'S FUMIGATION TABLE FOR NEW SOUTH WALES ORCHARDS.—*Continued*

Diameter	*Hight*	*Capacity*	*Cyanide*	*S. Acid*	*Water*	*Diameter*	*Hight*	*Capacity*	*Cyanide*	*S. Acid*	*Water*
			oz.	*oz.*	*oz.*				*oz.*	*oz.*	*oz.*
22	21	6,861	34	34	102	23	18	6,428	32	32	96
22	22	7,188	35½	35½	106	23	19	6,785	33¾	33¾	100
22	23	7,515	37½	37½	112	23	20	7,142	35½	35½	106
22	24	7,842	39	39	117	23	21	7,500	37½	37½	112
22	25	8,168	40½	40½	121	23	22	7,857	39	39	117
22	26	8,495	42	42	126	23	23	8,214	41	41	123
23	15	5,357	26½	26½	79	23	24	8,571	42½	42½	127
23	16	5,714	28½	28½	85	23	25	8,928	44½	44½	133
23	17	6,071	30	30	90	23	26	9,285	46	46	138

As a final caution, Mr. Allen says the full height and width of the tree should be taken after the tent is in place. Give a full charge of chemicals; it is better to give a fraction of an ounce too much than too little. Especial attention is called to Fig. 76, reproduced from Mr. Allen's report. For full directions for making and applying the gas, see Chapters II. and V. to X., inclusive.

Orchard work in Cape Colony, South Africa.—The fumigation of orchards in Cape Colony is largely due to the work of Prof. Charles P. Lounsbury, the Government Entomologist. The methods followed are very similar to those used in California. The conditions, however, governing the citrus industry of southern California are somewhat different from those found in Cape Colony. In California the black scale is one of the principal pests against which fumigation is conducted. This insect is practically unknown to the colonial fruit growers, and where it does exist it is kept in check by natural enemies. In point

of prominence, the red scale ranks next to the black scale in California. The red scale is also familiar to fruit growers in the colonial orchards. Considering all things, Professor Lounsbury is of the opinion that fumigation conducted by the contract system would be more advantageous to the colony than that done by local organizations. There are only a few slight differences in the methods of operating and handling sheet tents. The derrick-poles used in the colonial orchards for manipulating the tents are very much the same as those employed in California. The dome-shaped covers, known as bell tents, are used.

In a recent circular Professor Lounsbury makes the following statement: "Californians have demonstrated that they can grow citrus fruits at a profit, in spite of the heavy expense of fumigation. They fully realize that they may have to keep fumigating for an indefinite time. Their hope is, as ours, that efficient natural enemies of the scale insects will be found in the future. For South African fumigators it is especially recommended that changing poles be adopted for small sheets. A few colonial parties have fumigated for the white peach scale, *Diaspis amygdali*, and consider the remedy economical and satisfactory. If light weight sheets, handled with changing poles, were used it is probable that the gas treatment for this scale would become popular with a large number of our fruit growers."

New experiments at New York Agricultural Experiment Station.—Some timely and practical work has been recently completed at the New York Agricultural Experiment Station by Prof. V. H. Lowe, the entomol-

ogist. Through the courtesy of Director W. H. Jordan, the writer secured the following summary of the experiments.

In regard to these tests, Professor Lowe says: "Our work consisted principally of experiments in the orchard and with bud-sticks. The former were mainly for the purpose of determining the strength of gas required to kill the scale during the winter and spring, and incidentally the effect of the gas upon the trees, and the latter to determine the effect of the gas at different strengths upon fruit buds. The experiments in the orchard were divided into two series, as shown by the following summaries:

WINTER TREATMENT

Trees fumigated December 13-24; weather cloudy

TREES	*Strength of gas*	*Time of exposure*	*Results*
6 plum	0.18 gramme	½ hour	Scales not killed; trees uninjured
7 "	0.18 "	1 "	" " " " "
8 "	0.25 "	½ "	Many live scales found; trees uninjured
8 "	0.25 "	1 "	" " " " " "
7 "	0.30 "	½ "	Scales dead; trees uninjured
7 "	0.30 "	1 "	" " " "
1 peach	0.18 "	½ "	Scales not killed; trees uninjured
1 "	0.18 "	1 "	Tree dead
1 "	0.30 "	½ "	" "
1 "	0.30 "	1 "	" "

SPRING EXPERIMENT

Trees fumigated June 6-8 and June 16-24; weather cloudy

TREES	*Strength of gas*	*Time of exposure*	*Results*
4 plum	0.18 gramme	½ hour	Scales dead; trees uninjured
4 "	0.18 "	1 "	" " " "
87 "	0.25 "	½ "	Scales dead; trees uninjured, except three trees, which showed slight injury to foliage
3 "	0 25 "	1 "	Scales dead; foliage slightly injured
2 "	0.30 "	½ "	Foliage slightly injured
2 "	0.30 "	1 "	" " "

"From this summary it will be noticed that the gas at 0.18 and 0.25 gramme had little or no effect upon the scale when the fumigating was done in the winter; but that 0.30 gramme was strong enough to kill the scales. Also that the spring treatment resulted in killing the scales with the gas at 0.18 gramme and only one-half hour exposure. All of the plum trees treated were European varieties, and both plums and peaches were healthy, vigorous trees. We used the box fumigator shown at Figs. 43 and 81 in all cases. Fig. 81 shows our improved method of fastening the door on our fumigator.

"All of the trees were badly infested with the scale. Where the term 'scales dead' is used it means that after very careful search at various times during the summer following the experiment no live scales could be found. The statement that the trees were uninjured means that there was no effect on the foliage and fruit buds.

"*The buds* included in the fumigation experiment were of the following varieties: Apples—Jonathan, Fall Pippin, Oldenburg, Ben Davis, Fameuse, and Transcendant. Cherries—May Duke, Windsor, and Early Richmond. Pears—Anjou, Bartlett, Seckel, and Kieffer. Peaches—Elberta, Early Crawford, Blenheim, Early Rivers, Beersmock, and Alexander. Plums—Italian Prune, Reine Claude, Bradshaw, Shropshire Damson, Burbank, Yellow Spanish, Yellow Egg, Lombard, and De Soto.

"The buds were fumigated in a small box made especially for the purpose. The gas was used at the following strengths: 0.18, 0.22, and 0.30 gramme.

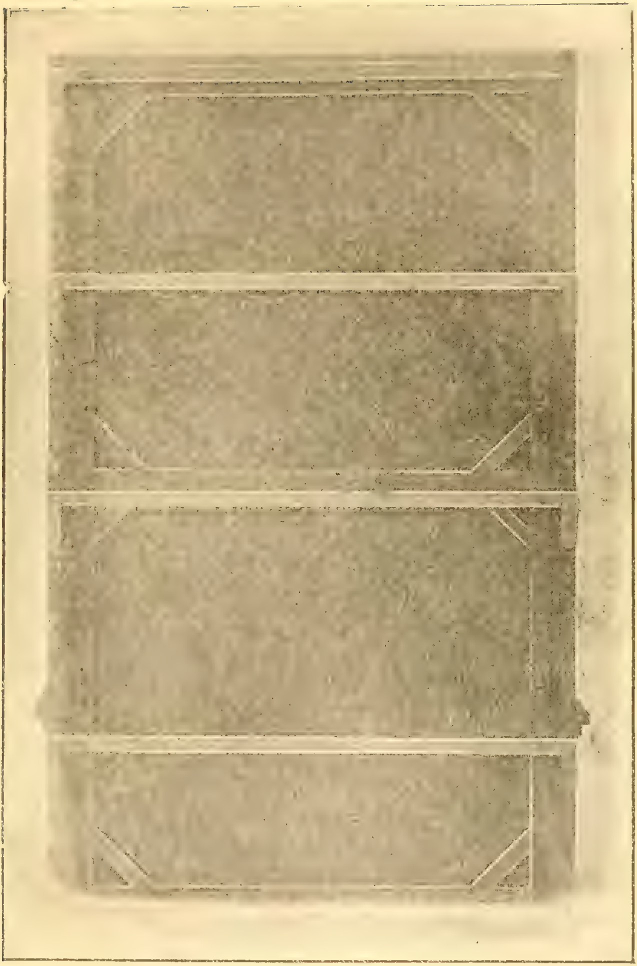

FIG. 79—IMPROVED METHOD OF FASTENING THE DOOR OF THE LOWE BOX FUMIGATOR

The exposure in each case was one-half hour and one hour. The bud sticks were divided into lots, so that each variety received the maximum and minimum exposures of the various strengths of gas. Our bulletin contains a number of tables showing the percentage in each case of the buds that set, and comparisons are made with checks.

"In all, 4,483 buds were treated, of which 78 per cent. set. The checks numbered 4,864 buds, 85.5 per cent. of which set, making a difference of 7.5 per cent. in favor of the checks. A careful examination of the tables shows that the gas evidently had no effect upon any of the varieties except peaches, which were slightly injured by the 0.30 gramme with an exposure of one-half hour and one hour. In all cases the growth of the treated buds was nearly or quite equal to that of the checks. The conditions of the treated buds were not quite as favorable, after they had been set into the nursery trees, as those of the checks. The treated buds were set a little out of season, somewhat later than the checks. They were also placed about four inches above the checks, where they were too high to be protected by the earth thrown against the trees during the fall cultivation. They were also placed on the furrow side of the trees, thus endangering them to injury during cultivation. These unfavorable conditions were probably, in large part, the cause for the failure of the treated buds to set equally as well as the checks."

Sirrine's folding fumigator.—Another type of fumigator has been developed and used by Prof. F. A. Sirrine, of the New York Agricultural Experiment

Station. This fumigator is about 11½ feet high and 8½ feet in diameter. As shown in Fig. 82, it is six-sided and is intended to fold up when not in use.

FIG. 80—THE SIRRINE TYPE OF FOLDING FUMIGATOR

Each of the six sides is rectangular and rigid. They are fastened together by hinges. When in use the whole fumigator is made rigid by a series of cross-braces. The top is held in place by a series of hooks.

The front of the fumigator can be opened as a double door of a width equal to the shortest diameter of the box. Unbleached sheeting so treated as to be gas-tight is used as a cover. Careful tests with this fumigator showed that it was practically gas-tight.

Fumigation of orchard trees near Albany.—A series of tests were made by Dr. E. P. Felt, State Entomologist, in the spring of 1900, with hydrocyanic acid gas for the purpose of ascertaining its efficiency and practicability in the latitude of Albany, N. Y. A canvas tent 6 x 6 x 8 feet with a fixed pyramidal hood 7 feet high, as shown in Fig. 81, was constructed of eight-ounce duck thoroughly oiled with boiled linseed oil. The rectangular part of the tent was supported on a light wooden frame, to reduce the variation in cubic contents as much as practicable. The tent was lifted with a thirty-foot pole and eight-foot gaff, and thus dropped over the tree. The hood was kept extended during the process of fumigation, as shown in the figure, illustrating also the manner of guying the pole and tent. The tent and apparatus for handling it cost about $38, but they could undoubtedly be made for less when several were needed. A good pole and gaff from near-by woods could be gotten at little expense. The bottom of the tent was provided with what Dr. Felt calls a "sod cloth." It consists of a flap six to eight inches wide, which was covered with earth to prevent the escape of the gas. An uncovered space was always left on the windward side for the insertion of the chemicals. The trees in these tests were exposed to the gas for 35 minutes. After fumigation the guy-lines were released, the sod cloth uncovered, and the

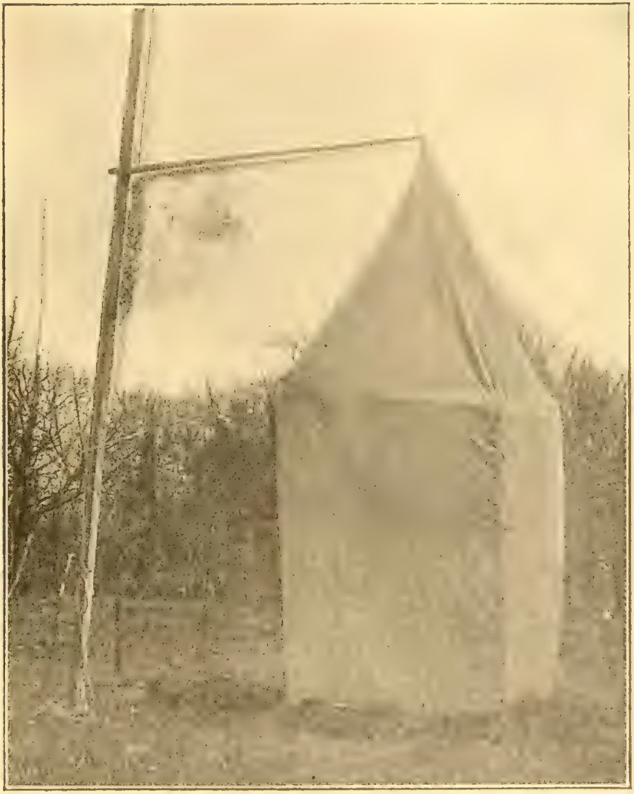

FIG. 81—FELT TYPE OF CANVAS TENT WITH PYRAMIDAL HOOD

tent quickly raised and dropped over an adjacent tree. It is quite important to have the pole on the windward side of the tent.

The trees were fumigated April 19, 20 and 21, using one ounce of potassium cyanide to 75, 100 and 150 cubic feet of space respectively. The trees fumigated were peach and pear, several varieties, and the buds were beginning to swell. The outcome of the tests showed clearly that the scale was all killed, even on trees where the gas was used at the rate of one ounce of cyanide per 150 cubic feet of space enclosed.

CHAPTER XX

ECONOMIC VALUE OF FUMIGATION

After a most careful consideration of the subject of fumigation with hydrocyanic acid gas from every point of view, the writer is of the opinion that it is indispensable in orchards, nurseries, greenhouses, mills, elevators, and various other enclosures where insect pests are to be destroyed. Nothing is more easily applied, and certainly no other material has been found so deadly to animal life. Its cheapness, quick diffusion, and thoroughness make it a practical remedy for ready use in many ways. In addition to the many methods cited, it can be used to good advantage for the destruction of animals, such as dogs, cats, etc., rounded up and captured in large cities. Such animals, including old or injured horses and cattle, could be easily and painlessly put to death by being enclosed in a room in which this gas could be generated.

It is not beyond human possibility that it may supersede the primitive method of hanging and the more modern idea of electrocuting criminals. Cells or death chambers could be made in any enclosure in which hydrocyanic acid gas could be easily generated, and the occupant painlessly and instantly put to death, without any of the horrors accompanying the gallows and electric chair. From the humanitarian point of view it certainly deserves consideration.

The following letters or quotations from scientific and practical men who have either used hydrocyanic acid gas or are thoroughly familiar with its properties and economic values are interesting in this connection. We have alluded to the early history of the discovery

FIG. 82—FUMIGATED CITRUS

Orchard of J. W. Henderson, near National City, California, only a short distance from the Stearns ranch, on which Fig. 83 was taken. Orchards about the same time. Note the difference.

of the gas as an insecticide in Chapter I. There seems to be some misunderstanding as to its first application to nursery stock. In the "Year-Book of the United States Department of Agriculture for 1899," Dr. L. O. Howard, Entomologist, is of the opinion that he first recommended the use of hydrocyanic acid gas as a dis-

infectant for nursery stock. The writer being aware of the use of this gas in California upon nursery stock as early as 1890, wrote Alexander Craw, State Entomologist and Quarantine Officer of California, who replies as follows:

First use upon nursery stock.—"Fumigation by

FIG. 83—SPRAYED ORANGE TREE
Orchard of W. F. Stearns, near National City, California
(Photograph by H. R. Fitch, July 18, 1901)

hydrocyanic acid gas was practiced in Southern California for the disinfection of nursery stock as early as 1889–90. Upon page 479 of the 'Report of the California State Board of Horticulture for 1890' the following reference to fumigating nursery trees is made: 'The Commission has used the utmost vigi-

lance in causing all Florida trees to be disinfected by both dipping and gas treatment. The red scale of Florida, *Aspidiotus ficus*, has been introduced on imported trees, but was without doubt eradicated by the gas treatment that the trees received.' This is over the signature of F. Edward Gray, at that time one of the Horticultural Commissioners of Los Angeles County, California. In June, 1891, a shipment of 325,000 oranges arrived at the Port of San Pedro from Tahiti, and were fumigated with hydrocyanic acid gas.

"During the above years the county commissioners in Southern California demanded certificates that nursery stock had been fumigated or dipped. Dr. L. O. Howard's history of fumigation, as printed in the 'Year-Book for 1899, United States Department of Agriculture,' is not correct. I notice on page 151 of that report that he considers, in 1894, he was the first to recommend fumigation of nursery stock before delivery to purchasers. I know that previous to 1894, as cited above, that hundreds of thousands of nursery trees had been fumigated in California before being delivered to purchasers. The fact of the matter is the United States Department of Agriculture had practically nothing to do with the discovery of the gas treatment, as Mr. Coquillett was not then in the employ of the Department."

Fumigate greenhouses regularly.—I fumigate my greenhouses and cold frames about four or five times a year with it, and have thus been able to keep down all insect and animal pests except the red spider. However, about 80 per cent. of the red spiders are killed by the regular treatment recommended, but to com-

pletely control the spider it is necessary to use water under pressure.—Dr. ALBERT F. WOODS, *United States Department of Agriculture.*

Olive trees fumigated.—In more than a score of instances in Southern California olive trees have been fumigated with the most satisfactory results. Trees which had not borne fruit for several years, after an application of fumigation, bore very heavy crops. The olive trees had been affected by black scale and smut which was totally destroyed by the application of fumigation. Peaches, apricots, plums, apples, and pears fumigated have brought large crops and superior fruit, not alone in flavor but also in size. Deciduous trees must be fumigated while they are dormant before the fruit buds or leaf buds begin to unfold or after the ripe fruit has been taken from the trees. This, in fact, we consider the best time to fumigate. It is a serious blunder to neglect to avail one's self of the advantages of fumigation in the belief that it is an expensive operation. Quite the contrary is the case. It makes but a small part of the orchardists' expense while the benefits ramify in every direction.—*The Rural Californian.*

Fumigation understood and appreciated.—A fumigated tree conserves its energy and produces clean fruit, having a brighter color and a better flavor than fruit which has gone through the process of washing and cleansing, and brings from 20 to 25 per cent. more in price in the market. The washing of oranges and lemons to remove black, purple, or red scale often breaks the skin and spoils the appearance and flavor of

the fruit. Fruit that has required washing is frequently unsalable when clean grown fruit is seen beside it. This is a fact well understood and appreciated in the districts where the application of cyanide gas is practiced. Any one wishing to convince himself of the vast superiority of fumigating over the old spraying methods only needs to visit the orchards of Duarte, Monrovia, Azusa, Covina, Pomona, and Riverside, and consult the Horticultural Commissioners. It may safely be stated that 99 out of every 100 of the Horticultural Commissioners in the country are heartily in favor of fumigation with hydrocyanic acid gas.—*The Rural Californian.*

"*Does it pay to fumigate?*" is answered by editor C. M. Heintz. He says: "This question is asked daily *The Rural Californian*, and we wish to state that there is nothing known at present which will assist the fruit-growers all over the United States as much to eradicate scale-insect pest as the process of fumigation. We in California have tried it for years, have been benefited by the operation, and permit us to say if it had not been for the fumigation procedure the citrus fruit industry of California would have been a lamentable failure.

"The actual and continuous use of hydrocyanic acid gas has demonstrated beyond the question of a doubt that by exterminating the scale insect the citrus fruit-grower has marketed a profitable crop. Districts like Riverside, Ontario, Pomona, Azusa, Orange, Tustin, Colegrove, San Dimas, Lamanda Park, and portion of San Diego County, will each testify to that which we state, namely, fumigation pays, and pays three hundred-

fold. The importance of freeing orange and lemon orchards of the red, purple, and black scale at this particular season when the insects commence to breed must be obvious to every grower. It means when the shipping season opens healthier trees, larger crop, and gilt-edge fruit, and an increase of receipts.

"These are facts and considerations that no commercial grower can ignore, and are of such vital importance that unless conscientiously practiced the chances are five to one that failure to realize a profit from his trees can be traced directly to neglect in this direction. We also know that the time has come when every nurseryman in this country will find fumigation a necessity in order to keep clean his nursery stock, not alone for his own protection, but for his customers as well."

In a paper read recently by J. W. Jeffrey, Horticultural Commissioner, Los Angeles County, at the Fruit Growers' Convention, he said: "Fumigation was more universal last fall than at any other time. It has been reduced to a science, and while the practice is not always successful, poor work is no longer tolerated without penalty upon the fumigator. There is little complaint of impure cyanide, but much of its improper applications. Daylight applications, or, more properly, warm weather fumigation, is under ban, but a few otherwise practical growers have not discovered it. Two or three of the leading citrus counties do this work at the treasury's expense, afterward collecting from the lands treated. Los Angeles still requires the orchardists to do their own fumigation. No new scale pests have developed since your last reports were

out, nor is there evidence that parasites have taken the contract to disinfect the orchards of Southern California."

The practice among the fruit-growers giving their fumigation to the lowest bidder is a bad one. The question should not be how cheap you will do it, but how good will you do it? And, again, the work should not be let by the tree, but by the hour. We do not deem it necessary to dwell upon the efficacy of fumigation, as we are confident that no one will disagree with us when we say that fumigation has been, and still is, the salvation of the citrus fruit industry of Southern California.—W. H. PAYNE, *Horticultural Inspector, California.*

Recently *The Rural Californian* quoted the following from Professor Cook: "Fumigation has been so long and favorably known that we do not need to speak its praises. 'By their fruits ye shall know them.' The fruits of fumigation are the thousands of dollars saved to the citrus growers of Southern California.

"We must remember that the foliage on orange trees is very dense, even more so than on the lemon, and it is not easy to reach every scale insect. Here, as I have often urged, is the rock on which the spraying process will split if anywhere. It is yet to be determined whether even in careful hands the spray can be thorough enough to be effective in the orange orchard."

The superiority of fumigation with hydrocyanic acid gas as a remedy for the destruction of red, black, or, in fact, almost any other variety of scale, is no longer a question of doubt with people who have tried all

methods for the destruction of scale pests. The increased cost of fumigation over spraying has, however, induced some orchardists in Southern California to resort to the cheaper method of spraying. Fumigation is the only remedy considered at all effective for the red scale. The amount of cyanide required to destroy black scale, if done at the proper time, is about one-half that required for red scale. In addition to my duties as Horticultural Commissioner, I am also Superintendent of Fumigation. I have been connected with the horticultural commission of Riverside County for the past six and a half years.—R. P. CUNDIFF.

Arizona.—In July, 1900, I employed this treatment for the destruction of the date palm scale, *Parlatoria victrix*, imported with a large consignment of some four hundred date-palm suckers from Algeria. We subjected the suckers to fumigations varying from 0.3 to 0.5 per cent. gas. The foliage of the plants, being of exceptionally hard and impervious nature, was not injured.—Prof. R. H. FORBES, *Director Arizona Experiment Station.*

Arkansas.—I am convinced that the treatment with hydrocyanic acid gas is an excellent method and destined to become of general service. I have been recommending it to nurserymen on occasion, though entirely on the basis of knowledge derived from the reports of others, such as your own.—Prof. ERNEST WALKER, *Entomologist Arkansas Experiment Station.*

Fumigation operations in Canada.—The following report was furnished the writer by Prof. William Lochhead, of the Ontario Agriculture College: In

Ontario we are operating under the San José Scale Ammendment Act, passed April 1, 1899, Legislature of Ontario, and the following are the chief clauses or sections relating directly to the inspection and fumigation of nursery stock:

Portion of the San José Scale Act.—The following are the sections of the San José Scale Act dealing with the fumigation of nursery stock, 62d Victoria, Chapter 35:

3. No person shall import or bring, or cause to be imported or brought, into the Province of Ontario, for any purpose whatsoever, any plant infested with scale.

4. No person shall keep, or have, or offer for exchange or sale, any plant infested with scale.

5. The owner or proprietor of any nursery shall not send out, or permit any plant to be removed, from his nursery, without the same first being fumigated by hydrocyanic acid gas, in accordance with regulations prescribed by order of the Lieutenant-Governor-in-Council. 62 Vic., Chap. 35.

6. No person shall sell, or dispose of, or offer for sale, any plant obtained, taken or sent out from a nursery unless the said plant has previously been fumigated in accordance with these regulations. 62 Vic., Chap. 35.

7. In case the Inspector finds scale in any nursery and so reports to the Minister, the Minister may thereupon inform, by writing, the owner or proprietor or manager of said nursery of the existence of scale in his nursery, and the owner or proprietor or manager of said nursery shall not thereafter permit any plant or plants to be removed from the said nursery until the Inspector reports to the Minister that it is safe in the public interest to permit the said nursery stock to be removed after fumigation. 62 Vic., Chap. 35.

Canadian fumigation regulations.—The following regulations have been prescribed by order of the

Lieutenant-Governor in Council, in accordance with the provisions of the San José Scale Amendment Act, passed April 1, 1899:

1. Fumigation must be carried on in a box, room, compartment, or house, suitable for the purpose, which must be air-tight and capable of rapid ventilation. The owner or proprietor will notify the Minister as soon as preparation for fumigation is complete. The Minister will thereupon order an inspection of the fumigation appliances. No fumigation under the Act is to be carried on until such inspection has been made and a satisfactory report sent to the Minister.

2. The Inspector, after examining and measuring the box or house, or other compartment in which fumigation is to be carried on, will prescribe the amounts of material to be used for every fumigation, and the instructions as to the same must be carefully followed out. The Inspector may, if thought advisable, supply the material for each fumigation in weighed packages.

3. The fumigation house (which shall include all apparatus or appliances used in the fumigation, such as generators, etc.) is to be subject to the orders of the Minister on the recommendation of the Inspector. Subject to the approval of the Inspector, the fumigation house may be on other lots than those on which the nursery stock are growing.

4. The fumigation is to be by hydrocyanic acid gas, produced according to the instructions of the Inspector and from such formulas as he prescribes for the purpose.

5. The fumigation is to be continued for a period of not less than forty-five minutes. After the expiration of this time, or longer, and when fumigation is complete, the house is to be thoroughly ventilated for fifteen minutes at least.

6. No person is to be allowed to enter the fumigating house until after the ventilation period has expired. Entering before may prove injurious, if not fatal, as the gas is a deadly poison.

7. The fumigation of buds and scions may be done in

fumigation boxes of not less than thirty cubic feet capacity, the same to be subject to inspection and approval.

8. Immediately after inspection of the fumigation house the Inspector will report to the Minister, and the Minister or Inspector will thereupon give permission in writing for the owner or proprietor to begin fumigation.

9. The owner or proprietor of every nursery will attach to every box and to every package of nursery stock a certificate as follows, and he will furnish every purchaser who so desires a copy of the same:

Certificate of fumigation.—This is to certify that this package of nursery stock, consisting of ———— was properly fumigated on or about the ——— day of ———— 1901, in accordance with the regulations prescribed by order of the Lieutenant-Governor-in-Council, in accordance with 62d Victoria, Chapter 35.

Amount of nursery stock fumigated.—We have in Ontario 117 names on the nursery list, but probably it would be more nearly correct to say that there are not more than 100 different nurserymen in Ontario, about four-fifths of the work being done by five or six of the largest nurserymen. Three out of every four nurserymen on the list do nothing more than a local business, but the four or five large concerns handle an immense amount of stock. It is somewhat difficult to get information from Canadian nurserymen regarding the amount of stock fumigated. However, one large nurseryman wrote me as follows: "It is a hard matter to give any accurate report as to the number of trees put through our fumigation house in a year, but would estimate that the trees would be about as follows: 200,000 apples, 25,000 pears, 40,000 plums, 35,000 cherries, 50,000 peaches, 50,000 ornamental trees and shrubs, 135,000 small fruits—making a total of 535,-

ooo." There are four nurserymen doing business almost as large as the one quoted. On the supposition that these four nurseries have about the same output and that they do four-fifths of the total business of the province, the amount of stock sent through Canadian fumigation houses would be in the neighborhood of two and a half million trees.

Fumigation in Ontario has been limited almost altogether to nursery stock, and practically nothing has been done on orchard trees. As far as the work in the nursery is concerned, I can say candidly that I am much pleased with the results. No trace of scale has yet been found on stock which has been fumigated. It is true that the first year the Act was in operation houses were built very hurriedly and frequently in a slipshod manner, and fumigation was also performed in a half-hearted and begrudging manner by the nurserymen, but I have found no trace of scale on nursery stock sent out that year. I have made no improvement over the methods and equipment outlined by yourself. I still follow your formula as amended and your method of constructing fumigation houses. Of course, individual nurserymen may have special contrivances for fixing the door and providing ventilation. I find by experience that the doors and windows are the parts of the house which are most apt to get out of repair.

Dr. James Fletcher, Dominion Entomologist, who has had charge of the fumigation houses at the ports of entry, writes that in the fumigation of the nursery stock in boxes at the border every bit of packing right down to the roots is removed, and only the roots are

allowed to be covered. He has found no instance, as yet, of living scale on any such treated stock.

Orchard fumigation.—One of Canada's fruit growers writes Professor Lochhead regarding the application of the tent system of fumigation on small orchard trees as follows: "We took a common apple barrel, making it fit the trees by using a width of ten-cent factory cotton well soaked in linseed oil, and while wet tacked it on the barrel. When dry it seemed to adhere to the barrel, making it practically air-tight. Then I headed back the three-year-old plum trees, so as to drop the sacks over them. For large trees we made tents 6 x 7 x 9 feet high, with posts at each end and sills and plates, these being well braced both horizontally and perpendicularly. Then I made a door, fastened to one post by three hinges, and shut to next post by a bolt in center and buttons at the top and bottom. I measured out factory cotton twenty-six inches long and sewed three widths together. This was oiled and tacked on while wet. We put on top piece first with tacks, then commenced side coverings where the door shuts, and brought it right around the frame, letting it lap two inches on top and leave a balance of ten inches to lay on ground, which is covered with earth. Then a common lath is nailed over the lap all around the top. When complete cut out the hole on the side the door hinges on, to allow the tent to pass over the tree. This will require three days to dry properly. Trees treated with the last tent were eight years old and had borne four crops of fruit. We had to head them back considerably. It takes three men to handle these large tents, but one man

can handle the small ones nicely. In fact, three men could manage ten large tents in one hour. From every appearance now the scale seems to be thoroughly killed and the trees to be doing well."

Certificate of fumigation.—Professor Lochhead says: "In Ontario there is one particular in which we differ from most of the states to the south of us, and that is in allowing the proprietor of every nursery to attach his own certificate of fumigation. Personally, I think this is neither fair to the nurserymen nor to the public, but the Department of Agriculture here in Ontario has never seen fit to appoint official fumigators to take charge of the fumigation at every nursery. The department allows the nurseryman to do his own fumigating and to attach a certificate of fumigation to every package sent out. The inspector, of course, and his assistants are moving about during fumigation time, and the nurseryman does not know when to expect a visit. Of course, we look after those nurseryman who live in infested regions. All the nurseries in the scale-infested regions are examined for scale, so that there is a double check on all stock sent out."

Nurserymen willing to fumigate.—"I find that there is quite a change of opinion regarding the merits of fumigation within the past year. I can say now, without hesitation, that nearly every nurseryman is perfectly willing to fumigate his stock according to directions, and to do it carefully. He feels that his reputation and his business are at stake should scale be found on his stock. We examine every fumigation

house twice a year, and we test it with smoke before we allow it to be used, in order to show the position of any possible leakage. For the first two years one or two nurserymen blamed fumigation for the death of many of their peach trees, but they have now become convinced that the damage was done by the very severe winter of 1898–99."

Connecticut.—I have not used the gas against San José scale, but have examined stock which had been fumigated and could find no living specimens a year later. We have used the gas in the tomato forcing house, using 3 and 2½ ounces of cyanide per 1,000 cubic feet of space to kill white fly, *Alerodes vaporarioum* Westwood. The plants were slightly injured at the top and every insect killed. Have also tried it in a barn to kill the clover-hay worm, *Pyralis costalis.*—Prof. W. E. BRITTON, *State Entomologist, Connecticut.*

Florida.—The following timely account of the work in Florida has been furnished us by Prof. S. A. Gossard, Entomologist of the Experiment Station: "We commenced some extensive experimentation in fumigating orange trees for white fly, *Alerodes citri*, in 1900. We found that the treatment destroyed the insects—in fact, practically exterminated them—with smaller charges than are used by the California people. Most of our work was done in the daytime, and while I have not seen the treated trees for several weeks a report by letter indicates that they are all right and have a good set of fruit. The trees dropped from one-fourth to nearly all of their leaves, but put out again immediately and seem to have a good set of

fruit. It would appear, therefore, that dropping the leaves from the trees is not so apt to work injury to the orange in Florida as in California. We fumigated trees of various sizes from mere bushes up to 30 feet in hight and 25 feet in diameter, using various styles of tents. The hoop tent proved most satisfactory for trees not over 12 feet in hight and of equal diameter, but for larger trees we used the bell tent, handling it by means of a new form of derrick. We ceased fumigation work when the trees commenced to blossom freely, and put the tents away.

"*Several hundred trees were fumigated*, and four or five times as many sprayed with resin wash and with a few other materials for comparison. The gas method is the more expensive to begin with, but we are inclined to believe it may be the cheapest in the end. I found that about seventy-five per cent. of the insects were killed by a single spraying with resin wash, but in examining thousands of insects upon many different trees that were fumigated I was able to find but a single living representative. I have no doubt that the practical application of the process to two or three of our orange-growing counties will mean a net profit of $250,000 to $500,000 annually inside of three or four years, if the treatment is generally adopted. We have not worked with deciduous trees, not because we believe it impracticable, but for lack of time up to the present. A number of our nurserymen use the gas in fumigating their nursery stock, and in a more limited way plants and shrubs, upon their premises. Nearly all of our nurserymen doing a large and extensive business have excellent fumigating appliances.

"*One form of fumigating box* in use by some of our nurserymen deserves notice. It consits of a smaller box resting inside of a larger one, about six inches of space separating the two between the bottoms and about the sides, which is filled with loose sand or clay. The top is either constructed with a similar space filled in with sand or earth, or may be of the usual pattern double-boarded with tarred paper between. This lid has a rim of beveled inch-board six inches deep, projecting downward and falling into the sand above mentioned, being brought perfectly into place by a wooden wedge above. This produces a box that is absolutely air-tight, and can never have an unsuspected leak of any kind in it.

"Judging from the evidence in my office, the gas treatment carefully applied is absolute protection against San José scale and other insect pests upon nursery stock. I have known instances where much nursery stock had gone forth infested when fumigation was either not practiced at all or was carelessly done, but have failed to learn of a single case of infested stock going out from the same nurseries after the stock was carefully treated."

Idaho.—No experimental work with hydrocyanic gas has been done at this station. The question of infested nursery stock has not been a pressing one. In this state I knew of one infested nursery, but it was abandoned. The owner made some inquiries of me about the subject of fumigation, and constructed a fumigating room, which he used for a year or two with success. As to fumigation of commercial orchards, there has been none of it here so far

as I know.—Prof. J. M. ALDRICH, *University of Idaho.*

Louisiana.—We are much interested in the use of this gas. Some fumigation of orange trees was made a few years ago, as noted in a special bulletin from the Louisiana Experiment Station entitled, "Insects of Orange." We have used hydrocyanic acid gas with good results for the cow-pea or bean weevil. The cow-peas were stored in a closed room and the amount of cyanide used was according to your own formula. We have arranged to fumigate plants coming into Louisiana, and it is our intention to use the gas much more extensively.—Prof. H. A. MORGAN, *Entomologist Louisiana Experiment Station.*

Massachusetts.—My candid opinion as to the efficiency of the gas method for the destruction of insects is that it should be much more widely used, but only by experienced hands. I believe it to be available for the fumigation of greenhouses, warehouses, and other places, but do not believe in its use where carbon bisulphide will do the work, considering the latter to be safer. The Experiment Station is strongly in favor of fumigation, but in the absence of any law on the subject can only make use of moral suasion.—DR. H. T. FERNALD, *Associate Entomologist, Hatch Experiment Station, Massachusetts.*

In Michigan cheap and reliable.—We now have excellent spraying laws and others, requiring the inspection of nurseries and orchards for San José scale and other dangerous insects and diseases, but it has not been found necessary to require the fumigation of all

nursery stock. The San José scale has only secured a foothold in a few localities, and even there has been confined to comparatively small areas. So far as is known, there is no San José scale within several miles of any of our nurseries. In one or two instances fumigation has been required where the black peach aphis has been found in a nursery, and under our present law it will be possible to compel nurserymen to fumigate their stock before it is sent out if the scale is found in a nursery, or in such close proximity that there is a possibility that the trees may be infested, even though careful inspection fails to reveal its presence. In case the scale continues to spread a move will be made to secure a compulsory fumigating law that will apply to all nurseries. At the present time it seems the cheapest and most reliable method of treating nursery stock, as well as for the destruction of many insects that are found in buildings.—Prof. L. R. TAFT, *Michigan Agricultural College.*

Urges law in Mississippi.—There has never been anything done with hydrocyanic acid gas in this state. We have no laws on fumigation of nursery stock, but I have been urging laws, and think I shall present the matter to the legislature.—Prof. GLENN W. HERRICK, *Entomologist Mississippi Experiment Station.*

Successful mill fumigation in Missouri.—Some nurseries have erected a fumigating house and have fumigated both the material entering and leaving the nursery, but no one knows that it ever had the San José scale in any case. Some greenhouses have also been fumigated, and always with success, but of course

this was for the ordinary greenhouse insect pests. I have never fumigated nursery stock or trees that had the San José scale with hydrocyanic acid gas and then made careful tests to see if all scales were killed, and hence I can not speak on that point. Several mills in this state have been fumigated with this gas, and with success, but it is difficult to get the mills aired out properly without danger, unless special arrangements be made to do this from the outside. This state has no fumigation laws, and probably will not for some time. We have only just succeeded in getting a law passed requiring stock entering the state to bear certificate of inspection.—Prof. J. M. STEADMAN, *University of Missouri.*

Nebraska fumigates doubtful stock.—Although we have done comparatively little in the way of using hydrocyanic acid gas for the purpose of fumigating nursery stock, a little has been done in this direction, chiefly by our nurserymen when they receive stock from abroad about which they feel a little dubious.—Prof. LAWRENCE BRUNER, *University of Nebraska.*

North Carolina.—I think that it is only a question of a very short time before fumigation will be one of the regular operations of the nurseryman. Where there are great interests at stake, I do not think that laws compelling fumigation are out of place but rather a necessity. Most people are too much inclined to look upon fumigation requirements only with reference to San José scale. It seems to me that it is equally fatal to other insects, and it cannot fail to be of very great benefit to the fruit grower. The cost of

fumigation to the nurseryman, as compared with the cost to the grower, for spraying, etc., is very small. Of course a system of fumigation will not do away with the necessity of spraying in orchards, but it will greatly decrease the loss that growers now sustain from the attacks of various insects.—Prof. FRANKLIN SHERMAN, Jr., *State Entomologist, North Carolina.*

North Dakota fumigated palms.—Owing to the fact that the number of fruit trees grown in this state is very small, and that scale and other insects have not yet appeared, its use has not become general. I have used the gas with very satisfactory results at this station to kill the scale on palms. I have known of its use with equally good results in the destruction of bedbugs in houses.—C. B. WALDRON, *North Dakota Agricultural College.*

New Jersey.—Personally I have done so little with the hydrocyanic acid gas that I do not consider myself entitled to any opinion as to its value, *i.e.*, no opinion formed as the results of original work. The truth is, I never like to duplicate another man's work, and as you have been doing the fumigation line most thoroughly I was willing to accept your results, devoting my time to other lines of investigation.—Dr. JOHN B. SMITH, *State Entomologist, New Jersey.*

New York.—I have not had much experience in the use of hydrocyanic acid gas on nursery stock, but from what I have used and from what I know of it in other respects, it seems to me to be one of the very best and perhaps the only satisfactory method of treating young trees for the purpose of killing insect pests upon them.

Were I to buy trees for personal use I should most certainly insist upon their being fumigated, especially if the grounds of my neighbor were badly infested with San José scale. I believe fumigation is a good thing aside from any suspicion of the presence of the San José scale, because it enables a man to start his trees as free from insect pests as perhaps any process through which he could put them.—Dr. E. P. FELT, *State Entomologist, New York.*

Ohio.—I have not had any reason to change my former opinion as to its efficiency. Used at the proper season, I do not know that there is the least danger to nursery stock, and I do not believe, if properly used, it is possible for a scale insect to pass through a fumigating house alive. We may say, as among other things connected with nursery work, and, in fact, everything else, much depends upon whether fumigating is done properly or improperly. All of the houses that I have had built have been provided with slat floors and we have generated the gas underneath. I find this is much more practical than any other way that I have tried. Of course for very small nurseries we have advocated a tight box, but this is only where plants like raspberries and blackberries are fumigated.—Prof. F. M. WEBSTER, *Entomologist Ohio Experiment Station.*

Pennsylvania.—I have not made a thorough canvass of our state in regard to the use of hydrocyanic acid gas, but know that many of our nurseries have constructed fumigating houses and are carefully subjecting infested stock to the gas treatment. This treatment is

the most effectual method we have to clean up nursery stock of its insect pests, and has given great satisfaction where it has been judiciously handled. There are cases in which the exposure to the gas was unnecessarily long, resulting in marked injury to the trees. It is useless, of course, to subject trees to the gas which are free from insects. The gas treatment should find favor in warehouses, flour-mills, etc., where vermin are to be destroyed and no life is at stake, but I have met with no experience in such places. I cannot recommend it for conservatories or greenhouses where a mixed lot of plants are grown. In my own experience I have found many kinds of plants suffer greatly in an exposure that is too weak and brief to kill all of the red spiders or mealy bugs. If a single house can be closed off and the stock is wholly of one kind of plants, as violets or chrysanthemums or carnations, it is possible to so adjust the treatment that no injury will befall the plants and the insects will be destroyed.—Prof. GEORGE C. BUTZ, *Horticulturist Pennsylvania Agricultural Experiment Station.*

Rhode Island.—I believe that the gas treatment for the destruction of insects upon nursery stock is the only efficient method for the destruction of certain of the pests, and personally were I to buy plants for a large orchard, or for use in the orchards which I already have planted which are now free from San José scale, I would most surely buy them from some nursery which would fumigate trees before shipment. I believe that as the efficiency of this method of treatment is more fully understood and appreciated by warehouse and flour-mill owners that this will become

the method in vogue for the destruction of insects which harbor in such buildings.—G. E. ADAMS, *Assistant Horticulturist Rhode Island Experiment Station.*

Virginia.—In my several bulletins on the San José scale and reports as state inspector for the same, I have mentioned more or less frequently the subject of fumigation. We have never attempted fumigating orchards or plants of any kind, except nursery stock in closed houses. Our present formula to each 100 cubic feet of space in room for fumigating nursery stock is as follows: Fused potassium cyanide, 98 per cent., 1 ounce; commercial sulphuric acid, high grade, $1^1/_5$ fluid ounces; water, 3 fluid ounces. This has proved very satisfactory, and thus far we have no instance in which it has damaged the stock. I am happy to say no instance has come to our notice in which the scale has survived treatment by the above formula.—Prof. WILLIAM B. ALWOOD, *State Entomologist, Virginia.*

Sound Advice.—In an address before the New York Fruit Growers' Association, L. T. Yeomans, a prominent New York fruit-grower, said: "Our firm has not planted a tree during the past two years which has not been fumigated with hydrocyanic acid gas. We do the work ourselves cheaply, quickly, and without injury to even peach trees, notwithstanding the assertion of some nurserymen that it is unsafe, expensive, and dangerous. A nurseryman in western New York who has fumigated for several years all the nursery stock he sells, says the expense to him does

not exceed 25 cents per 1,000 trees of regular one dollar size. If all planters would refuse to buy trees which had not been fumigated, the nurserymen would see it for their interest to fumigate. I am happy to say that there are some nurserymen who fumigate all their stock. No trees can be shipped into Canada without fumigation, and yet there are some who raise a cry about the hardships it would be for them if compelled to fumigate stock sold to the grower, yet these same nurserymen find it to their interests to comply with the Canadian law rather than abandon their trade across the border."

Views of a practical fruit grower and nurseryman.—The following statement was received from C. M. Hooker, the senior member of the well-known nursery firm Hooker, Wyman & Co., of Rochester: "I am strongly in favor of the fumigation of all nursery stock, when it can be safely done, before dissemination or planting. This should be done by the nurseryman, but to be perfectly safe I personally fumigate all stock planted on our place. I have done so for years, and cannot afford to take any risk of infestation of San José scale from the carelessness of others. That nursery stock should be fumigated before planting is evident from the rapid spread of this pest when it is neglected and the serious loss of all those who plant infested stock. All infested nurseries should be compelled to fumigate their stock if the people are to be safe in buying their trees.

Answers objectors.—"The objections which are made to a law requiring fumigation by some nurserymen I think are not of great force.

"*1st.* They object to the cost. We reply that it is proven that it is not over 25 cents per 1,000 trees.

"*2d.* Delay of shipment. This cannot be over a few hours.

"*3d.* Nobody knows that the process is effectual. Many tests prove that it is the best known and never fails if properly done.

"*4th.* Dangerous to employees. No one was ever seriously injured by the gas, and with a little care it is perfectly safe.

"*5th.* Inspection is sufficient. This has been proven a failure in many cases. Of course, inspection is necessary and good so far as it goes, especially in locating the pest in nurseries and orchards.

"*6th.* Dangerous to nursery stock. This does not prove to be the case when properly conducted. One nursery firm in Geneva has fumigated over one million trees without damage to one.

"*7th.* Wait for a federal law. Of course this is only an excuse for delay. We shall never get a federal law, and in any event should take care of our own scale.

"*8th.* Not constitutional. Give us the law, and we will risk that.

"*9th.* Other states will retaliate by passing similar laws. Well, we are not certain what other states may do, but we should do what is right to protect our state from the San José scale and let other states do what they think best for their interests. There are other and more important interests than the nursery interests, yet it certainly is for the interests of the nurserymen to keep New York State as free as possible from the scale.

"10*th*. It is an injury to the nursery business to agitate the subject. This has been proven false by a large concern in Geneva, who advertise that they fumigate all their stock, and paste large cards on their boxes, stating '*This stock has been fumigated*,' and have very largely increased their business since they adopted this process.

"The San José scale is doubtless with us to stay, but it is our duty to do all that we possibly can to keep it under control, and in my opinion we cannot be too careful about it for the interests of the fruit growers and every one else in the state. The serious damage to orcharding from this pest may be judged from a letter I have received from a prominent fruit-grower in western New York informing me that he expected to destroy about fifteen acres of valuable bearing trees this season because they were ruined by San José scale."

Common-sense view.—The following letter from Isaac C. Rogers, of the Rogers Nurseries, is a plain, straightforward statement of facts: "Our fumigatorium is a room inside the packing-shed. The great bulk we usually fumigate in a frost-proof and air-tight room after we are ready for billing out in the spring; then the small lots dug from time to time are run into the smaller room, with an opening at the top for the escape of the gas through the roof after done. The expense of fumigating is a small matter. The bother is a small matter compared with the feeling of security and the fact that after the trees have been through that deadly stuff they go out through the country carrying no mischief and trouble making insects. The

extra expense of handling is really a small item. The only way it bothers us is sometimes in loading a car there will be a shipment to get off that has to have a few trees fumigated, and then with thirty minutes out of an hour taken up with the fumigating one has to jump around pretty lively to make connections. But the rush and jump are only parts of the nursery business and all in the same line, so we do not mind it. On an average it costs us 25 to 30 cents per thousand for the actual fumigation, including the extra handling.

"We have been fumigating now for three or four years and have had no trouble from loss of trees as yet, although we were assured by the antifumigators that we would have our trees to replace. We are careful to fumigate the trees when dry, and for that reason like the fumigating room as a part of the packing-shed much better than to have it as a separate building. If the trees come in during a wet day they can be allowed to dry before being put in the fumigator, and it is far more convenient to be able to step into the room from the packing-shed during any kind of weather.

"The objection generally made by nurserymen is from the fact that a very large part of the nursery stock grown in western New York does not go direct to planters, but is shipped here and there to dealers and nurserymen all over the United States. Nurserymen in other sections must have their stock shipped early so they can reship to their customers, probably back in New York. In order to get this done and the trees planted before it freezes up, they have to be dug before they are fully matured. Some nurserymen fear that

fumigation will injure them in this condition. There will be kicks along the line, for frequently trees are shipped and reshipped, sold and resold, several times before they are eventually planted, and no doubt frequently set a few miles from where they were grown. At the other end of the season there are always lots of people who forget all about ordering until the trees begin to grow or come into bloom, and then it is too late to fumigate safely at the usual strength. These two extremes seem to block the way and prejudice many nurserymen against fumigation.

"We do not have to depend upon the notions of other nurserymen hundreds of miles away. We can dig, fumigate, and pack our trees when the right time comes. This accounts, in part, for our not being 'in the ring,' as it were, fighting our own interests, as some nurserymen have been doing. In some cases with a large majority of tree growers in New York there is really no connection or kindred interest between them and the fruit grower. Their product is frequently sold before digging-time, to go in car-load lots to other nurseries hundreds of miles out of New York, and little or nothing do they care what becomes of the trees afterward or whether they are planted in New York or in South Africa."

Protects customers.—We are thoroughly convinced that fumigation is most necessary in order that the grower of nursery stock may supply his customers with trees and vines absolutely free from all insect life. While most nursery stock grown in this section is not infested with San José scale, yet all is more or less infested with aphis and other troublesome forms of

insect life, that can but be deleterious to the tree if allowed to remain thereon in an active condition. For the past two years we have fumigated everything that we have sent out except evergeens, and so far have never detected any injurious effects.—THE R. G. CHASE COMPANY, *Nurseries, New York.*

Utah.—We believe this is the most efficient treatment that nursery stock can be given. If the building is air-tight and the chemicals are mixed in the proper proportion, it is undoubtedly destructive to all kinds of insects and no harm results to the stock. After putting gas into the building we leave our stock stand from one-half to three-fourths of an hour, then throw the double doors wide open, and allow the building to ventilate from fifteen to twenty-five minutes before attempting to remove the stock. We believe it pays us to run all nursery stock through our cyanide house. We have treated from two to three hundred thousand trees annually for the past three years. In 1901 we expect to treat half a milllon. If one had more stock than this it would be advisable to build a larger house. We think it quite necessary to have the roots of the trees comparatively clean. If they are covered with dirt, especially clay soil, the gas may not penetrate to the insects, especially woolly aphis. Do not think our building cost to exceed $50. —VAN METER, HARNESS & CO., *Proprietors Davis County Nurseries, Utah.*

Utah.—I have followed your directions for fumigating, which have proven very satisfactory. I have had no opportunity for experimenting with scale, but

find the gas a sure remedy for woolly aphis and other insects.—D. M. MOORE, *Moore's Nurseries, Utah.*

Opinions of orchardists on fumigation in New South Wales.—Bevan Brothers, of Galston, write W. J. Allen, the government expert, as follows: "We have fumigated some 1,500 trees since this time (July) last year, and the results have been very satisfactory. Without doubt nearly every scale has been killed, the trees are healthy, and the fruit clean. We formerly sprayed from three to four times a year, tried several preparations, and never got thorough satisfaction out of any. Occasionally patches of live scale do remain on trees that have been fumigated, but, as far as we can judge, this has only happened where fruit with scale on it has pressed against the side of the tent, or where the dose of acid has not been quite sufficient to poison the scale on the lower limbs.

"Several of our neighbors having seen the results on our trees have had tents made, and set to work cyaniding. This is surely the best proof of its value. You are aware that we use a cheap tent made of calico, costing wholesale about 1*s*. 3*d*. per yard, double width. So far this has answered admirably. Tents 10 feet in diameter by 12 high cost from 30*s*. to 35*s*. This reduction in the cost of the tent really made fumigation possible to us. We have had to thank your department for many things, but for none are our thanks more deserved than for teaching us cyaniding."

R. L. Sheppard, Wesbank, Emu Plains, says in same report: "I was prompted to enter upon what seemed at first rather an arduous undertaking, viz., the fumigation of my citrus trees for the destruction of

scale, by a practical demonstration given by W. J. Allen, government fruit expert, who at the same time placed at my disposal a large amount of useful information for my guidance at the start. The first difficulty which presented itself was that of procuring tents—how many to get, what sizes, and where to get them at a reasonable cost. Firms in Sydney asked a price that was practically prohibitory. In my difficulty I applied to Mr. Walter Bevan, of Galston, who at this time was having his trees treated by this process, and he it was who put me in the way of getting them at a moderate figure. The least expensive method is to buy the material at some wholesale house and have it made up at home. For the purpose nothing could be better than 'circus-tent calico,' both for lightness and durability. At present the wholesale price is 1*s.* 5½*d.* per yard of 6 feet wide.

"In my opinion no grower should bother with tents, but have the material made into square sheets the sizes he requires. They are easier to make than tents, answer the same purpose exactly, and are much more readily placed over the trees. The number to get and the sizes will naturally depend on the trees the grower has. I got four tents and two sheets, each sheet being 40 x 40 feet, and with this number two men can do from 30 to 50 trees each day. I began fumigating about the end of January last, and instead of doing the work at night, which is generally accepted as the proper time, I did all mine by daylight. Orange trees badly infested with scale, I found, lost a large portion of their leaves, those with less scale a much smaller quantity. Having the cyanide broken up too

finely, and thus causing the gas to generate very quickly, seemed to tend to defoliation as much as anything. However, a very strong, new growth started, and the trees soon assumed a splendid appearance. Curiously enough, lemon and mandarin trees, though treated in the very hottest days, lost no leaves at all. Fumigation, no doubt, is the only royal road to clean trees—it absolutely blots the red scale out, and if done before the fruit is too large, a clean crop is assured, as the expansion of the fruit causes the scale to drop off. Brown olive scale is decimated, but not always altogether destroyed, though it looks as if, of the two, it would be easier to kill. So far I have treated 1,800 trees of various sizes, and I am sure growers will be pleased to know that the average cost per tree, including labor, price of tents, chemicals, etc., only amounts to 7¼*d*. Thus for 7*d* you get a healthy tree and clean fruit. How much more is this worth than a sickly tree and unmarketable fruit? To show how fumigation is regarded on Emu Plains, I can inform those who are in doubt that since my neighbor growers witnessed the effect of the treatment here some have already commenced, and others contemplate doing so."

M. Brown, of Messrs. Rodgers & Co., Galston, writes Mr. Allen as follows: "We have fumigated this year some 1,800 trees, and are entirely satisfied with the result. We started fumigating the first week in May, and a live scale cannot be found on any of the trees done. Fully 50 per cent. of the scale have been cleaned off the trees, and I hope to see the greater part of the remainder cleared off before the bulk of the fruit is marketed. Of course, you will understand

that May is too late to commence fumigating to obtain the best result, but we could not start earlier, and next year I intend to start early in February, so that the oranges, while still growing, will throw off the dead scale. My reason for starting in February is that I have done some experimenting, and have closely watched the result, and feel sure that citrus trees done in that month will be almost absolutely clean by May. I did some twelve or fourteen of the worst trees I could find in the orchard fourteen months ago with the government tents which you lent me, and at the present time they are almost perfectly clean ; what little scale there is on them has only come in the last two months.

"As you know, I have had some experience with spraying, and have tried practically every known spray, and also had Mr. Chomley up here experimenting with different sprays, and I have no hesitation in saying that spraying is a thing of the past, and quite out of date compared with fumigation, as the fumigation gives a ten times better result, and is not nearly so costly, once you buy the tents, and these are not very expensive. I bought strong unbleached calico, double width, wholesale, at 1*s.* 2*d.* per yard, and find this will hold the fumes as well as canvas, if it is not blowing a strong wind. I got 200 yards, which made nine tents of various sizes (but all of them are a good size), and cut the stuff out myself in the following manner : Cut out a circle 6 feet in diameter, then one length of calico 30 feet long, and sew round the circle ; then cut out another length 30 feet long, and join on the other piece and sew up the seam ; this will give

you a tent which will cover a well-grown ten-year-old orange tree, provided the tree is not more than 13 feet high.

"What I should like to see the government do is to get together a large plant (say, twenty-five tents) and employ four men to manage it, and go round to various orchards in each district and fumigate them, charging the owner the cost of cyanide, etc., labor, and enough to allow for wear and tear in tents, and interest on their outlay for same, as I feel sure many orchard owners would be only too glad to have their orchards done, but they have not the capital to spare to get the necessary plant, as one wants a fair number of tents to do the work quickly. I find myself and one man can manage fourteen tents comfortably. Your formula of one cyanide, one acid, and three water is not sufficient to work off the cyanide in forty-five minutes, so I use one, one-and-a-half of acid, and three. You are welcome to publish all of this if you think it of any use, and to say that I strongly urge growers to go in for fumigating, as there is nothing else to compare with it in efficiency and cheapness."

CHAPTER XXI

FUMIGATION WITH CARBON BISULPHID

THE fact that carbon bisulphid volatilizes readily, has fumes heavier than air, creates an atmosphere in which no animal life can exist, and can be used without injury to edible materials, all combine to make it one of the very best substances for the destruction of certain subterranean insects and other undesirable animals. For killing insect pests in stored grains and other materials in bulk it has no superior. Its vapor will penetrate to the lowermost cracks and crevices in a granery, carrying the death-dealing atmosphere with it. It can be used economically where hydrocyanic acid gas cannot be employed on account of its heavy vapor.

First use of carbon bisulphid to destroy insects.—During 1856 and 1857 M. Doyere used carbon bisulphid as an insecticide. He demonstrated that it could be used to destroy weevils and other pests in corn and barley without injuring the grain either for planting or edible purposes. Since that time it has been used for combatting various insect pests. At first the cost of carbon bisulphid precluded its general use as an insecticide on a very extensive scale. Largely through the efforts and inventive genius of Edward R. Taylor, a manufacturing chemist, a grade known as "Fuma carbon bisulphid" was placed upon the market a few years ago. It is now the standard for insecticide pur-

poses and is sold at a price within reach of those who desire to use if for economic purposes.

Chemical properties.—Carbon bisulphid is a colorless liquid resembling water. It is formed by the union of two elementary particles of sulphur with one of carbon (charcoal); thus the chemical symbol CS_2. It is made on a large scale by a new electric process invented and patented by Edward R. Taylor. The fumes of burning sulphur are passed over red-hot charcoal and the resulting vapors are condensed to a liquid by cooling. Mr. Taylor's new plant at Pen Yan, New York, has a daily capacity of 20,000 pounds at present. The liquid is one-fourth heavier than water. Its specific gravity is 1.29 at the freezing temperature of water. It is very refractive, reflecting light much more readily than water when its surface is disturbed. It is extremely volatile and evaporation is rapid when the surface is exposed to the air. The temperature of the liquid and the air, as well as the evaporating surface, determines the rapidity of evaporation. By covering the surface of carbon bisulphid with water, which is lighter, evaporation can be prevented.

Carbon bisulphid is not necessarily dangerous to the skin, but when the fingers or hands are frequently moistened with it the skin becomes rather dry and harsh and liable to crack or chafe. On account of its volatility it absorbs considerable heat. Perfectly pure carbon bisulphid has an acrid taste and a rather sweetish, not disagreeable, etherial odor, similar indeed to that of ether or chloroform. Pure carbon bisulphid will not injure or stain the finest garments or fabrics. It can be poured directly upon food stuffs without im-

pairing their edibility. All trace of the odor disappears quickly when such products are exposed to the air. The ordinary commercial article has a slightly yellowish tinge due to its impurities, which also give it a rank fetid odor that is extremely obnoxious. When an impure article is used, a slight residue may be left after the evaporation of the liquid. Such a grade will stain fabrics, and it should be poured upon food stuffs with care, though its vapor will do no harm. Liquid carbon bisulphid is not explosive, and there need be no fear of handling it, provided the vessels are perfectly tight. It should be kept where there is no fire in a dry place, so the cans will not rust. Carbon bisulphid boils at 115° F. One volume of the liquid is said to give 375 volumes of vapor upon evaporation.

Properties of vapor.—Owing to its heavy properties the vapor of carbon bisulphid can be poured from one vessel to another, like water. It is 2.63 times heavier than air. It diffuses quite readily through the air, as can be perceived by its odor. It has a tendency to seek lower levels, and consequently will be more dense as it works downward. This fact should be borne in mind, as it has an important bearing upon the application of this material. It is the opposite of hydrocyanic acid gas, which is lighter than air. Carbon bisulphid in both liquid and vapor form is an efficient disinfectant. Meats have been kept in its atmosphere for many weeks. The disinfectant is the same gas as is formed by burning sulphur or brimstone.

Inhaling the gas.—The extreme effects of the vapor of carbon bisulphid if inhaled are giddiness, vomiting, congestion, coma, and death. The material can be

used in mills, warehouses, and other enclosures with perfect safety. A reasonable amount of the vapor can be inhaled, while the liquid is being distributed in a building without injury to the operator. From personal experience in making many practical applications of carbon bisulphid in buildings, the writer has never experienced any ill feeling or bad after-effects from the gas. The sense of smell is the first affected. If one is confined in a room where the gas is being generated, for a short time the olfactory organs are benumbed or deadened. As the oxygen in the lungs becomes exhausted, the heart-throbs become more rapid. The mind becomes sluggish, while hearing and sight are weakened. This is usually followed by dizziness. The sensation is not disagreeable, and a person has no immediate desire to get out of the gas. A person in this condition should leave the building being fumigated at once and freely inhale fresh air.

Mr. W. E. Hinds, who has had some experience with the practical application of this gas, in a recent Farmers' Bulletin (No. 145) by the United States Department of Agriculture, says: "Owing to the effect of the gas upon the heart action, it may be well to caution persons having any trouble or weakness about the heart against taking any extended part in the application of the bisulphid. It should be clearly understood by those who use it that the action of the gas is somewhat poisoning as well as suffocating. Should the operator persist in remaining in the room after the dizziness comes on, he will be in danger of falling, and, if not discovered, he will soon suffocate. Even if he should get out safely, the ill effects will be

more marked and a severe headache, at least, might ensue. If upon the approach of dizziness, the operator goes at once to a window, or better still out of doors, an abundance of fresh air will in a few minutes remove all ill effects, and no injury will result from the experience. The inhalation of the fumes can be somewhat retarded by tying a wet handkerchief tightly over the face. This, however, merely diminishes the amount of air taken into the lungs without affecting the proportion of vapor contained therein."

When obliged to enter a room in which the air is charged with any considerable amount of vapor, Mr. Hinds makes use of the following simple device, which is perfectly effectual: A large paper bag holding 20 quarts or more is tied tightly around a short piece of tubing of glass, rubber, or metal. When inflated, the bag contains sufficient air to enable one to respire into it for several minutes without discomfort. Being very light, it can be carried by the tube in the mouth, thus leaving the hands free for any work desired. Carbon bisulphid can be handled with much greater safety and far less fear than is possible where the user knows there is danger but does not know just what the danger is. The danger from its use is practically of the same kind as that from gasoline, which is in common daily use. The danger is very much less, however, since every precaution is taken to keep carbon bisulphid from the proximity of fire, while gasoline is used principally in connection with it.

Commercial uses.—Although the insecticide properties of carbon bisulphid were discovered by Doyere in 1856, and tested three years later by Baron Paul Thé-

nard, it remained for M. Cornu and M. Mouillefert, two French investigators, to determine its real value in this connection nearly twenty years later. They experimented upon many species of insects representing various groups, paying particular attention to the grape phylloxera, the most serious pest to the vineyards of France. They found that an atmosphere containing one part of carbon bisulphid and nine parts of air killed insects within a few seconds when confined in the vapor; and that one part in 254 parts of air was also fatal in about one and one-quarter hours.

The application of carbon bisulphid for the destruction of insects in mills, elevators, and other places where large quantities of grain is stored is of recent origin. Its extensive use to kill gophers, ground squirrels, and other noxious subterranean and undesirable rodents is a comparatively new method.

In the arts it is employed as a solvent of sulphur, phosphorous, oils, resins, caoutchouc, gutta-percha, etc. It is indispensable in the manufacture of rubber and waterproof goods. In the manufacture of woolen goods it is used to abstract oils and fats from the wool. It is not considered an extra hazardous material, otherwise it would not be so extensively used.

Work in France against Phylloxera.—The treatment of vines in France with carbon bisulphid for the destruction of phylloxera is very extensive. Some years more than a quarter of a million acres receive treatment. Upon being introduced into the soil at some depth below the surface the liquid evaporates as it does in the open air, but much more slowly. The vapor diffuses through the air spaces of the soil. It

produces an atmosphere fatal to all insects within its reach. The rapidity of evaporation, extent of diffusion, and persistence of the vapor in the soil vary widely in different soils. It evaporates most rapidly in a warm, dry, sandy soil. The persistence of the vapor is also shortest in such a soil, and it diffuses so rapidly most insects will survive an ordinary dose. The treatment cannot be successfully applied on such a soil in its dry condition. On the other hand, diffusion is slowest in heavy, wet, clay soil; and when such soil is saturated with water it is almost entirely prevented. Moisture lowers the temperature and decreases the permeability of the soil ; it also prevents the evaporation of the liquid, and thus retards diffusion. Between these two extremes there is a medium condition of moisture which is most favorable for treatment.

Action in different soils.—Sandy soils permit an even but too rapid diffusion of the vapor. Rocky soils are not of even texture, and naturally the vapors follow the lines of least resistance. Heavy clay soils, when very dry, are usually much broken by cracks and fissures, which may run from the surface to a considerable depth. Through such fissures the vapor escapes rapidly without permeating the soil to any extent, and its insecticidal value is therefore slight. But when such a soil is well moistened it is even in texture and very favorable to treatment. The depth of the soil is an important factor in determining how much carbon bisulphid must be used for a given area. If the soil is shallow and the subsoil very dense and impervious, it is evident that much less liquid will be required to

produce a death atmosphere than will be needed in a soil of much greater depth. In soils of the same character and condition the amount needed will be proportional to the permeable depth of the soil. In heavy, compact soils increase the number of injections and diminish the dose; in light, deep, permeable soils decrease the number of holes and increase the dose.

In field experiments with the grape, using plain carbon bisulphid in quite fresh soil, vines withstood 105 c. c. of carbon bisulphid, nearly 4.4 ounces, divided equally among three holes placed about 16 inches from the base of the vine and at a depth of about 20 inches; but 180 c. c., 7½ ounces, proved fatal to the vines. In warmer, drier, more shallow soil a dose of 90 c. c. per vine, similarly placed, proved fatal. After considerable rain, when the ground was quite wet, a vine withstood 260 c. c. of carbon bisulphid, and some vines are said to have withstood 400 c. c. The treatment should never be applied for some time after plowing or cultivating, as a firm, compact, moist surface is much more favorable to the retention of the vapor. For the same reason about fifteen days should be allowed after treatment before cultivation is resumed. If the soil is either very wet or dry, treatment should be withheld. To be in the most favorable condition for treatment, the soil should be quite moist and moderately permeable, with a firm, even surface, well compacted by rain and having a depth of at least eight inches.

The extent of diffusion of the vapor determines the distance apart at which the injections must be made to reach all parts of the soil evenly and effectively. This

varies considerably with the amount of the dose, the temperature and humidity of the soil, and other conditions. It has been found more satisfactory to employ smaller and more frequent doses rather than a few large ones. A dose of 5 or 6 grammes, $^1/_5$ to $^1/_4$ ounce, is believed to be thoroughly effective through a radius of from 12 to 20 inches, though it may penetrate much farther than that. The general rule is to make three injections per square meter, nearly $1^1/_5$ square yards, in light soils, and four injections in heavy soil. The holes should be at regular intervals, so as to cover the ground evenly, and never nearer than one foot to the base of the vine. To be effective all the ground must be treated.

On account of the liability of injuring the vines it has been found best to make the treatment in two small applications, separated by an interval of from six to ten days. This decreases the density of the vapor, but continues its action for a much longer time. It removes the danger of injuring the vines, and gives even better results upon the insects than would be obtained by one large dose. The total amount of carbon bisulphid to be used should be divided into as many equal parts as there are injections to be made. The holes for the second treatment should be intermediate between those for the first. The depth of the holes will depend somewhat upon the depth and permeability of the soil. The average depth is about one foot. Holes 16 inches deep are desirable on very permeable soil.

Treatment may be applied at any season of the year; but, as it is followed by a slight check in growth, it

should not be applied either at the flowering or fruiting season, as the check would injure the crop most at those seasons. The injury to the vines results from the killing of the tender, fibrous, feeding roots. It would therefore be better to apply the treatment before these roots have started in early spring, or after they have become hardened in the fall. The condition of the soil usually favors the spring treatment, and the condition of the insect is said to make it more susceptible at that time.

Amount to use per acre.—To secure extinction it is usual to apply about 300 grammes, nearly 10 ounces, per vine, using 150 grammes in each of two applications ten or twelve days apart. This will kill ninety-nine out of every hundred vines. In cultural treatment the amount of the liquid to be used varies from 140 to 265 pounds per acre.

Instruments for application.—One of the principal difficulties in the first use of carbon bisulphid was to force the vapors to the desired depth. When first used below the surface it was poured into holes formed by driving an iron bar with a maul. The demand for a more convenient, accurate, and rapid working instrument was soon met by the invention of the pal-injector by M. Gastine. This instrument was later improved by M. Vermorel. The carbon bisulphid is placed in a large chamber, from which an outlet leads down through a series of valves, so adjusted that the amount of each discharge can be exactly regulated as desired, and opens near the tip of the pointed bar. The instrument is forced into the ground by the handle and the pressure of the foot upon the spur to a

depth of about one foot; the central plunger is then pressed down and the desired amount of the liquid is discharged; the instrument is withdrawn, and the hole closed with the foot, or, as is usual in extensive work, another workman follows with a rammer, with which the holes are closed, and the soil at the same time is firmly compacted. It is said that two men working together in this way can make between 2,000 and 3,000 injections per day. One acre will require on the average from 10,000 to 12,000 holes. Plows have also been devised for injecting carbon bisulphid into the the soil, but they are not altogether satisfactory. The same methods can be applied to other subterranean insects and underground creatures.

Root-maggots and root-worms.—Both the larvæ and pupæ of the cabbage root-maggot are destroyed with carbon bisulphid. Prof. M. V. Slingerland, of Cornell University, has determined these points with accuracy, giving the details of his experiments in bulletin form. (Bulletin No. 78, Cornell University Experiment Station.) Where used for the root-maggot the hole should start 3 or 4 inches from the stem of the plant and run down obliquely a little below the roots, where the liquid is deposited. The dose required varies from a teaspoonful for each small plant to a tablespoonful for large plants, an equivalent of about one-quarter of an ounce in the former case and one ounce in the latter. One injection will be sufficient if made in time. The conditions of the soil noted under phylloxera treatment will have practically the same influence in this case.

A similar method of treatment will be equally

effective against the grape root-worm, *Fidia viticida*. To facilitate the application of carbon bisulphid the McGowen injector was invented. It is a very convenient instrument, and can be adapted to nearly all uses of carbon bisulphid for underground insects.

Destroying ants in lawns and other places.—Usually by careful observation the common ants, excepting, perhaps, the little red ants frequenting houses, can be traced to their outside homes. The treatment consists in making one or more holes in the nest with a stick or iron bar, one to two feet deep, and pouring into each hole a couple of ounces of carbon bisulphid. The hole should be closed immediately. The vapor may be exploded at the mouth of the hole with a match, in order to drive the fumes deeper into the chambers. If the latter method is adopted, the hole should be covered with fresh earth immediately after the explosion, so as to put out the fire and retain the fumes. Otherwise a large portion of the gas will be burned and the efficiency of the treatment considerably lessened. After the explosion the vapor burns with a colorless, invisible flame. Carefully observe this point before an attempt to recharge a nest is made. Otherwise an explosion might follow, with serious results to the operator. If a large area is infested the holes should be about one and one-half feet apart each way. After the carbon bisulphid has been applied the ground should be thoroughly watered to prevent too rapid diffusion of the fumes.

White grubs and mole crickets, sometimes found in lawns and gardens, can be treated in the manner de-

scribed for ants. One ounce per square yard divided between three or four injections will be satisfactory. The most favorable time for treating the grubs is after they descend in the ground in the fall and before they come up again in the spring. In midsummer many of the small insects near the surface will escape injury from treatment. Carbon bisulphid may also prove useful for the destructive nematode worms.

For borers in trunks of trees clean out the mouth of the burrow and insert a small quantity of carbon bisulphid and close the hole with thick clay or other material. The borers are easily killed without injury to the tree. The saving of time fully pays for the small amount of carbon bisulphid required. A spring-bottom oil-can may be used for applying the liquid.

Melon plant-lice can be treated successfully with carbon bisulphid. The method consists in covering the young vines with tight boxes, 12 to 18 inches in diameter, made of wood or paper, and introducing under each box a saucer containing one or two teaspoonfuls of carbon bisulphid. The vines of older plants may be gathered about the hill and folded under large boxes or tubs. In such cases a greater but proportional amount of material must be used. The covering is usually left over the plants from three-quarters to an hour. With 50 to 100 boxes a field may be treated quite rapidly. This method of introducing the bisulphid can be improved by boring a hole about one inch in diameter in the middle of the top of each box, and fastening a small bunch of cotton-waste, rags, or any absorbent material. By fitting a stopper

in the hole the box is ready for use. In placing it over a plant, be careful that the edges set firmly into the dirt. Remove the stopper, add the desired amount of liquid, and close it quickly.

Fumigation of mills and other buildings.—Carbon bisulphid can be thrown directly upon grain without injuring its edible qualities, and will not effect its vitality in the least. In mills it can be used about the machinery, spouts and elevators with perfect assurance that the manufactured products will not be damaged. I know of no instance where the slightest deleterious effect has been realized by persons applying it in mills, although they unavoidably inhale some of the fumes.

The amount of liquid to be used depends (1) on the size of the building, (2) on its tightness, and (3) on the magnitude of the attack. Where the building is reasonably tight and but slightly infested, one pound of carbon bisulphid is sufficient for every thousand cubic feet of air-space enclosed. If it is somewhat open or badly infested the amount should be doubled. When applied to bins containing stored grain, one pound of liquid to every hundred bushels of grain is commonly used; but if the insects are very abundant, twice this amount should be used.

Methods of application.—A number of ways for using carbon bisulphid have been suggested and tested. The most effective manner of applying it in mills consists in simply pouring the liquid into shallow dishes, such as soup-plates, pans, or wooden vessels, and distributing them about the building. Bits of cotton-waste saturated with the liquid should also be thrust into spouts,

elevator legs, machines, and other places where the pests usually congregate in great numbers. Spraying or throwing the liquid broadcast into badly infested corners, on machines, and other pieces of apparatus where the pests are particularly abundant, has been attended with very good results.

Time to do the work.—Saturday afternoon is the best time for fumigating a mill or large building. After sweeping from top to bottom, all fires about the premises should be extinguished and the building closed as tightly as possible. The vessels and cotton-waste should be previously distributed, so there will be no unnecessary delay. The number and distribution of the vessels will depend, as already stated, upon the condition of the mill and the severity of the attack. It is best to begin with the lowest story and work upward. The operators can then keep above the settling gas. When the bisulphid has been applied throughout the mill it should be locked and kept closed until the following Monday morning. All windows and doors should then be thrown wide open and the building allowed to air an hour or more before fire is started in it. Where the building is large and a great quantity of material has been used, it is wise to have a watchman stationed outside to prevent any one from entering or loitering about the building during fumigation.

Practical application.—As a guide to those who may use this method, I quote several letters from practical millers who have used carbon bisulphid successfully. The superintendent of a large Pennsylvania milling company, whose name I withhold by request, wrote me

the following letter. It is a valuable contribution, and should be read by every wide-awake miller and grain-dealer: "We have delayed answering your valued letter until we were able to report the result of our efforts to destroy the weevils in our mill. Following the line of your advice, we ran our stock down low and thoroughly renovated our mill from top to bottom, cleaning all reels and purifiers. We then fumigated the whole building with carbon bisulphid. We distributed 300 soup-plates about half filled with bisulphid through the mill, and saturated balls of cotton with the same material and placed them in all the reels and purifiers. We did this on Saturday night, closed the mill tight and left the weevils to their destruction.

"We opened the mill Monday morning and thoroughly ventilated it before entering it. We found we had destroyed thousands of the pests, and in the reels and purifiers we had killed them all. In the course of a few days a few insects began to show up in the cracks in the floors and in dark corners. Two weeks later we repeated the dose in the same manner and obtained about the same results. In the mean time we whitewashed the mill from top to bottom (that is, every place that could be covered), putting on a good heavy coat. We have reduced the bugs to a very small number, and eternal vigilance is the order of the day with us.

"We are still fighting them. Our plan is to keep a stock of bisulphid on hand outside of the main building. We do not think it is advisable to store it in the mill. Wherever we find a place infested by the weevil we use it freely, taking care to do it when the mill is

shut down and closed up tight. We find the best results from the use of carbon bisulphid can be obtained by spraying it on the floors and in infested places. We think when placed in plates it does not evaporate quick enough to produce the death atmosphere required."

Extra precautions.—The writer has called attention to the dangers from fire when the fumes of carbon bisulphid are present. Special reference is now made in connection with the treatment of buildings with this gas. Not even a lighted cigar or pipe should be allowed in the building. Always do the work in daylight. No artificial lights of any kind are allowable. Even electric lights should not be used. When turning them on or off there is always danger of producing a spark, which might prove disastrous. Heated steam-pipes should be allowed to cool before the application is made. Electric fans should not be run. There should be no heat of any kind in the building while the vapor is enclosed. Owners of adjoining premises should be informed of the nature of the work being done and cautioned to be on their guard during the hours of fumigation.

Germination of seeds.—Fifty-four varieties of seeds, including the principal grain and garden seeds, were recently treated with carbon bisulphid by the Division of Botany, United States Department of Agriculture. Every precaution was taken to insure uniformity in the seeds of each lot, treated and untreated. The treated lots were exposed to an atmosphere saturated with carbon bisulphid vapor for forty-eight hours. Under the most extreme treatment, the severity of

which would never be equaled in ordinary practice, a majority of the varieties tested showed no injury and germination was practically the same in each lot. Seeds of the grass family appeared more tender than other kinds. Experiments were also conducted upon grain in bulk, using the liquid at the rate of one pound to 100 bushels of grain. The exposure lasted twenty-four hours. No injury could be detected in even the most delicate seeds.

Treating seed and grain in bulk.—Such seeds as corn, wheat, rice, peas, beans, cow-peas, and others are frequently attacked by insects and seriously injured or entirely destroyed. No insecticide now known is equal to carbon bisulphid for the destruction of such pests. Seeds or grains to be fumigated should be placed in barrels, bins, or rooms. The enclosure should be tight. Apply the carbon bisulphid as directed above, at the rate of from one to one and a half pounds for each 1,000 cubic feet of space. A bin or room ten feet each way, or 1,000 cubic feet, will hold about 100 bushels of grain. A barrel or small enclosure will require a larger proportional amount unless it is very tight. Place the liquid on top of the seed in shallow vessels. A small bin or barrel should be covered with heavy blankets to better retain the vapor. Close the receptacle for 24 or 36 hours. The germinating power of the seed will not be injured in the least, other conditions being normal. Rye, millet, barley, and crimson clover are the most liable to injury and should receive proportionately a less amount.

As many of these pests enter the seeds in the open field while the grain is in shock, stack, or growing, it is

desirable to fumigate large bulks of grain, etc., as soon as possible after it is put in store. This is especially true of wheat, corn, peas, and beans, particularly those to be used for propagating purposes later. Larger warehouses or granaries can be successfully treated if the directions cited above are followed. With large bulks of grain the vapor may be left for two or three days, or even longer.

Stimulating effects on plants.—It is an acknowledged fact that the growth of plants on soil following treatment is unusually good. Treatment of a corn-field yielded an increase of 46.8 per cent. in the grain and 21.73 per cent. in the stover. Potatoes showed an increase in weight, varying from 5.3 per cent. to 38.7 per cent. In a series of experiments upon corn, oats, beets, potatoes, and clover, much the same results were obtained, but the most marked increase was in the clover. It was found that the vapor was not detrimental to the active bacteria causing the nodules upon the roots of this legume, but rather seemed to favor their multiplication. Furthermore, it was found upon these same plats that the beneficent influence of the treatment was quite apparent the following year, though less marked than it had been the first year.

Effect upon fruit.—Recently an Italian investigator, M. F. Sestini, has determined the effect of carbon bisulphid upon fresh fruits. His conclusions are as follows: One volume of carbon bisulphid evaporated in 10,000 volumes of air produces no alteration in the character of the fruit during an exposure of twenty-four hours. After the treatment flavor is normal and

it appears that the perfume of each fruit gains in fineness and intensity. The color of fruits not entirely sound becomes deeper, especially upon those parts of their surfaces which have been bruised during ripening or from defects in packing; it is thus very easy to choose carefully, rejecting such fruit as could not have been preserved.

Woolens, furs, and clothes.—Woolens, furs, and other wearing apparel may be placed in a tight, paper-lined trunk or a large box, and treated with carbon bisulphid. When stored away, place a shallow dish holding a few ounces of the liquid on the goods, and spread some newspapers over the top and close. No further attention will be required; but if the box is not tight, it will be necessary to repeat the dose every few weeks during the hot weather. An excellent plan is to provide a large packing-chest having a close-fitting cover. By boring a hole through the cover and fastening a small sponge or bit of cotton-waste inside, it may be fumigated by pouring the bisulphid through the hole upon the absorbent when it is necessary. Carpets, rugs, robes, etc., can be freed of all pests if fumigated for a few days in such a box. The odor is less persistent in the goods than that of moth balls, tarred paper, or other materials. When used on fine fabrics it will not stain or injure the most delicate articles, provided the pure carbon bisulphid is gotten.

Such household pests as cockroaches, fish moths, bedbugs, fleas, carpet-beetles, etc., can be destroyed in tight rooms by a liberal application of carbon bisul-

phid. Frequently the holds of ships are cleared of pests in this manner. The liquid is quite generally used for the destruction of a number of insects commonly called museum pests. When specimens are inclosed in fairly tight showcases or trays, they can be easily treated in the cabinet or drawer. As a measure of safety, in many museums the fumigation is done annually, regardless of the absence or presence of the pests.

Killing prairie-dogs, gophers, squirrels, etc.—For the destruction of small animals that burrow under ground, such as prairie-dogs, gophers, woodchucks, squirrels, moles, rats, mice, etc., nothing has been used with such gratifying results as carbon bisulphid. Some years ago, when the writer was located at the University of Illinois, several plots of land on the Experiment Station farm were overrun with gophers. Their presence greatly interfered with the experiments being conducted, and carbon bisulphid was used to destroy them. The holes or burrows were located. A piece of cotton about the size of a hen's egg was saturated with the liquid, thrust into the hole, and closed with a small piece of sod and loose dirt stamped down firmly. A few hours later several of the burrows were opened, and in every case a dead animal was found with its nose thrust into the cotton. It evidently had made an attempt to escape the deadly vapor.

Amount to use.—A pint of carbon bisulphid, a little more than a pound, is sufficient to treat twenty ordinary burrows. The amount used, however, depends somewhat upon the size and character of the burrow. If rather small and in a somewhat compact

soil, a small quantity will suffice ; but if the burrow is large, rather shallow, and with several openings leading to the surface, much more liquid will be required. As a rule, a small wad of cotton, wool, old rags, excelsior, even dry grass or a corn-cob, saturated with a little less than one ounce of the liquid and heeled in the holes, will do the work. A Nebraska farmer says he uses dried balls of horse manure. They hold the liquid well, are less expensive than cotton, and easily obtained.

On the Laramie Experiment Farm in Wyoming ninety-six burrows were treated during the month of July. The applications were, with few exceptions, made in the evening. The next day the treated burrows were visited, and in no instance had the earth which had been used for plugging the opening been disturbed. A second and third visit to these burrows found them securely plugged. In two instances some animal, presumably a ground squirrel, had made an effort to dig open the burrow from the outside. The opening extended only to the ball of cotton, when, from all appearances, the task was given up. In forty-three instances gophers (squirrels) were driven or seen going into the burrows and treated at once. None of the animals ever again saw daylight.

It is best to perform the work in the evening, otherwise some of the treated burrows will be dug open by out-lying squirrels. The remedy can best be applied in the spring, while the ground is yet compact. Where the balls of dried horse-dung are used the cost is reduced and the rounded masses carry the chemical beyond the reach of the dirt used in closing the hole.

At the Idaho Experiment Station a test was made upon thirty holes. Twenty-seven of these were undisturbed; two were scratched open from the outside and one from the inside. Several holes were afterward dug open and in each was found a dead squirrel.

Expert opinions.—There have been many exaggerated reports about the nature of this chemical compound. In this connection I can do no greater service than to quote a letter from Edward R. Taylor, the leading manufacturer of carbon bisulphid in this country. He says: "I have seen a great many very random statements on the subject of the inflammability of carbon bisulphid. One says, 'Use the same care as with gunpowder'; another says, 'it is a very explosive liquid.' These are both very misleading statements with reference to its properties. I have quoted the statements, however, in my printed matter for the reason that farmers and many others use the goods, and will be sufficiently startled by such statements to be careful and have no light or fire about.

"Nearly everybody is now familiar with gasoline. The properties of that liquid and carbon bisulphid are practically identical, in that both are inflammable but neither of them explosive. The vapor of either of them mixed with air is explosive, but the liquids are not explosive. I have shipped thousands of pounds of bisulphid to millers, elevator operators, and farmers, and have yet to have the first report of any disaster, even of the most trivial character. Need I say more? My directions are explicit. Do the work Saturday afternoon by daylight. Have absolutely no light or fire of any kind about. Close the building and leave

the bugs to their destruction till Monday morning. Then open doors and windows, and thoroughly ventilate before going to work."

The vapor of carbon bisulphid takes fire in air at about 300° F. and burns with a faint blue flame, difficultly visible in daylight, but evolving considerable heat and decomposing the carbon bisulphid into carbon dioxide (CO_2) and sulphur dioxide (SO_2). The latter is the familiar gas given off by the burning of sulphur matches and is a strongly poisonous, suffocating gas which should not be inhaled. Carbon bisulphid vapor mixed with three times its volume of oxygen, or an amount of air containing that amount of oxygen, forms a mixture which is very highly explosive upon ignition. As 21 per cent. of the air is oxygen, one volume of liquid carbon bisulphid evaporated in 5,357 volumes of air would form such a mixture. An atmosphere composed of one volume of carbon bisulphid vapor to approximately 14.3 volumes of air is liable to violent explosion in the presence of fire of any kind whatever, or a temperature of about 300° F. without flame. We have here about the maximum danger-point from explosion in the use of carbon bisulphid.

Exterminating the flour moth.—My experience with the Mediterranean flour moth is of nearly seven years' standing. Until I took charge of my mill six years ago I had never seen nor heard of the insect, and when I found it here and learned what it was I doubted whether such a delicate little creature could do any more harm than a house-fly. I soon had evidence, however, of its capacity for mischief. For one day it

actually succeeded in shutting down our 100 h. p. engine by so choking conveyors, elevators, etc., with its webs that the wheels simply could not turn. This is an absolute fact. Meanwhile I had written to Prof. W. G. Johnson, the expert, about the pest and sent him a sample of its work. When the mill was finally choked to a standstill I knew what to do. I first put six men at work taking spouts and elevator legs apart and cleaning them thoroughly, and when that was done I had them go for the machines. It took us just six days to get cleaned up. Under the Professor's advice I had provided ten gallons of carbon bisulphid and about 200 tin pie-plates. Saturday afternoon we closed and packed all the doors and windows, distributed the plates throughout the mill, filled them with bisulphid, and "let her simmer" until Monday morning. Opening up the mill we found dead moths everywhere.—L. C. SCHROEDER, *New York*.

Some insurance companies were a little uneasy lest they should suffer loss by fire originating from the use of carbon bisulphid in mills. The *American Miller* investigated this subject by sending letters of inquiry to all the important millers' insurance companies in the United States and Canada, and did not learn of a single fire known to have been caused by the use of carbon bisulphid. The properties of the fluid have been fully described above, and millers have been warned to keep lights and fire away from the vapor, lest an explosion should occur. The fact that it has been used so long without fires being traceable to it gives strength to the opinion that millers, out of consideration for their own lives, have heeded the warning

and have been exceedingly careful in applying it. It should not be stored near the mill, as this increases the fire risk. A break in the can or drum might unexpectedly release fumes which would soon fill the mill.

Death to weevils.—Carbon bisulphid settled the weevil family in our mill. It was so full of them we thought we would have to abandon it for a time. Bisulphid cleaned them out and saved us. — A. WILHELM, *Ohio.*

All a miller wants for weevils and other mill pests is "Fuma" carbon bisulphid. It knocked them out for us.—J. C. BRIGHT & SON, *West Virginia.*

Exterminating moles.—When there were indications of moles to be seen, we found the run, and inserted a ball of cotton thoroughly saturated with "Fuma" in each opening. The earth was firmly packed over the opening. As these little animals have so many turns to their paths, I followed the run and put in eight more well-saturated cotton balls, always being careful to pack the earth firmly over the opening. Anything worth doing at all is worth doing well. We were about discouraged, as the moles were fast destroying a lawn we were anxious to save. We determined to give "Fuma" a trial, and am glad we did, as we were soon rid of moles.—A. B. SWAN, *Long Island.*

Destroying woodchucks.—I have always had my share of woodchucks, and I never could get rid of them until last season. I got an ounce of carbon bisulphid, used one-half on three burrows, and in about three hours all three had been dug out. I used the other half where an old one had young; the next morning I

dug out the hole and found them dead. A neighbor joined with me and we got twenty pounds of carbon bisulphid. One pound is enough for fifty, and not one has ever dug out of the hundreds that we have treated, unless there was some opening that we missed. Pour from one to two spoonfuls on anything that will absorb the stuff, push it into the hole three feet, push down a sod nearly to it, hoe on earth and tramp down. Treat all main outlets the same, and next summer one will be puzzled to find the place.—A. B. JOHNSON, *New York.*

Destruction to prairie-dogs.—I cleared a pasture of eighty acres with fifty pounds of carbon bisulphid and not a dog showed up all summer. Five or six came from another town late in the fall, but I soon put them to sleep and they have not waked up yet. It is the cheapest means by which prairie dogs can be destroyed. —THOMAS SHEFFRAY, *Nebraska.*

I have destroyed the prairie-dogs on about eighty acres at a cost of $30. This one operation increased the value of the land $500. One pound of of carbon bisulphid will treat twenty-five holes.—ISAIAH LIGHTNER, *Platte County, Nebraska.*

We killed the prairie-dogs on about a hundred acres with five gallons of carbon bisulphid. It is the best, as well as the cheapest, way of getting rid of them.—*Kansas Farmer.*

Rats and mice easily destroyed.—Some years ago the writer's attention was called to a granery in Maryland, under which a large number of rats had burrowed into the ground. The building was double, set on posts

raised about eighteen inches above the ground, with a driveway between. The earth underneath was completely honeycombed with burrows. Two pounds of carbon bisulphid were secured. Wads of cotton, varying in size from a hen's egg to one's fist, were saturated and thrust into every burrow that opened on the surface. The holes were securely closed. Only in two instances were the holes opened by their occupants, and these were quickly destroyed by a second dose. Wherever a burrow is found about any building it can be treated in the same way.

In fields where rats and mice frequently do serious injury to corn and other grain in shock they can be destroyed by saturating a small wad of corn-silk or husks and pushing them in the holes after the shock has been overturned. Frequently cellars and root-houses are infested with rats. A few ounces of carbon bisulphid used as indicated will exterminate them.

How carbon bisulphid is put up.—This material is usually put up in steel drums holding fifty pounds each and costs about ten cents a pound. It can be purchased from local dealers in smaller quantities. In such cases the price is about double that quoted, or even more. The grade known as Fuma carbon bisulphid is cheaper than the chemically pure article. Only in rare cases is it necessary to use the pure bisulphid. For general insecticide purposes "Fuma" is the standard and entirely satisfactory. The writer has used large quantities of it with most excellent results in every case.

CHAPTER XXII

LAWS REGULATING NURSERY AND ORCHARD INSPECTION AND FUMIGATION

FOR many years California has been protecting her horticultural interests by strictly enforcing laws enacted for that purpose. That State was the pioneer in this movement, and the benefits arising therefrom have been very marked. Not only have California orchards been greatly increased in area, but many dangerous insect pests and diseases have been kept out by the vigilance of the quarantine officers. With the invasion of the San José scale in the Eastern States, various local laws have been passed to meet conditions prevailing in many states or territories.

In Maryland, Delaware, and Canada the fumigation of all nursery stock with hydrocyanic acid gas is required. North Carolina has recently adopted fumigation methods, and nurserymen in that State will be required to fumigate all trees offered for sale. In New York and Montana the inspection laws require fumigation of all nursery stock if thought necessary. In Oregon all apple, pear, or other stock grown on apple roots must be fumigated before delivery. Conditions are such that other states will soon be obliged to incorporate in their laws the fumigation require-

ment with rules regulating the inspection of nurseries. Maryland has done more in perfecting fumigation methods in the East than any other State. The Canadian government practically adopted the Maryland system, after sending a representative to familiarize himself with details and methods used in that State.

The following states and territories have no laws at present, December 1, 1901, governing the transportation or inspection of nursery stock: Alaska, Alabama, Arizona, Arkansas, Kansas, Maine, Minnesota, Mississippi, Nebraska, Nevada, New Hampshire, Oklahoma, Rhode Island, South Dakota, Texas, Vermont, and Wyoming. If special information is desired relative to inspection or the shipment of nursery stock into any of the above states or territories, it can be secured through the Directors of Experiment Stations.

A brief synopsis of the horticultural laws and rulings regulating the inspection of nurseries and orchards, and the shipment of nursery stock in the various states and territories is given herewith. Most states require copies of the authorized certificate of inspection to accompany and be attached to each consignment of nursery stock. Oregon, Colorado, Idaho, and Montana require all nursery stock entering their borders to be inspected by local inspectors. Canada receives no stock, as noted in Chapter XXIII., except through certain ports of entry, where it is fumigated. This is true also in Montana and Oregon. All stock shipped into New York from other states must be fumigated. Nurserymen desiring to ship into those states should bear this in mind and look up the points of entry. Duplicate certificates are required for ship-

ment of nursery stock into Georgia, Michigan, Ohio, North Carolina, South Carolina, and Virginia.

California.—The State Quarantine Officer at San Francisco, Cal., must be notified of the receipt of nursery stock, pits, fruits or vegetables, which must be held for inspection. Any consignment found infested with injurious insects or plant diseases shall be treated under the direction of the quarantine officer. If the shipment is found to contain pests not established in the State, the entire consignment shall be destroyed or sent out of the State. Any nursery stock affected by yellows or rosette will be destroyed or returned to the consignee. The county boards of horticulture cause the inspection of nurseries, orchards, vegetables, vines, and fruits. Owners are obliged to suppress injurious insect pests if found on their premises.

Colorado.—The regulations for the prevention of diseases in orchards and nurseries are placed in the hands of the State Board of Horticulture. County inspectors are appointed, and they must examine all shipments of nursery stock before delivery. If found infested, they shall be disinfected, destroyed, or removed from the county, at the option of the inspector. An orchard, nursery, fruit-packing house or storeroom found infested with injurious insect pests or diseases dangerous to fruit trees, vines, or the horticultural interests in general, must be disinfected or treated according to the direction of the county inspector. If he shall neglect or refuse to treat or destroy as directed, the owner shall be guilty of maintaining a nuisance, and liable to a fine. If found guilty, the inspector has

a right to abate the nuisance at the expense of the owner.

Connecticut.—The State Entomologist, who shall have an office at the Experiment Station at New Haven, Conn., under the direction of the Board of Control of the Connecticut Agricultural Experiment Station, has charge of the nursery and orchard inspection in that State. All nursery stock shipped from other states, counties, or provinces shall bear a certificate. In case a shipment is made not bearing a certificate, it can be inspected by the State Entomologist at the request of the owner, and if found free from pests and disease it may be received, and the cost of inspection deducted from the consignor's bill for said stock. All nurseries in the State shall be inspected at least once a year, and if no serious pests are found a certificate to that effect is given to the owner. If pests of a dangerous character are discovered, the owner is required to suppress the same under the direction of the State Entomologist. This act went into effect July 1, 1901.

Delaware.—The orchards and nurseries of the State must be inspected at least once a year by the inspector authorized by the State Board of Agriculture at Dover, Del. Nursery stock shipped into the State must be accompanied by a certificate. Since August 1, 1901, nurserymen are required to fumigate all stock offered for sale or shipment.

Florida.—A penalty for knowingly selling diseased nursery stock is provided by the statutes, but they are inoperative. The Entomologist at the Experiment

Station at Lake City, Fla., issues certificates to nurserymen in the State upon request.

Georgia.—A State Entomologist is appointed by the State Board of Entomology, with headquarters at Atlanta, Ga. The Board formulates rules for the treatment or destruction of trees, and prevent whenever possible the introduction of any pests considered dangerous to the horticultural interests. A certificate from the State Entomologist must accompany all stock shipped by nurserymen of the State. Nurserymen from other places desiring to ship into Georgia must file a copy of their accredited certificate of inspection with the Commissioner of Agriculture at Atlanta, Ga. When the proper certificate is filed by nurserymen from without the State, the State Board of Entomology will issue its certificate permitting shipment of stock into the State. Official tags, bearing a facsimile of this certificate, are required and will be furnished by the Board at cost, viz.: Fifty cents for the first one hundred and twenty-five cents for each additional hundred.

Idaho.—A general State inspector and ten district inspectors are appointed by the State Board of Horticulture at Moscow. These officials are required to inspect orchards, fruit houses, etc., and if pests of a dangerous nature are found the premises may be disinfected or the fruit may be destroyed, at the option of the officer in charge. Peach, nectarine, apricot, plum, almond and other trees budded or grafted on peach stock grown in districts where peach yellows or peach rosette are known to exist are prohibited sale or distribution in the State. All nursery stock offered for

sale from other sources must be examined by the inspector, and if not approved it must be destroyed. To all shipments of nursery stock intended for the State shall be affixed a label showing the contents, together with the name of the shipper and the locality where the stock was grown.

Illinois.—The State Entomologist, whose office is at Urbana, Ill., has full charge of the nursery and orchard inspection. Nurseries are inspected annually and certificates granted, copies of which must accompany all shipments. It is unlawful for transportation companies to deliver nursery stock of any kind within the State unless such stock is accompanied by a certified certificate approved by the State Entomologist.

Indiana.—All the nurseries of the State shall be inspected at least once a year by the State Entomologist, whose office is at Lafayette, Ind. Certificates of inspection are given to nurserymen within the State, and copies of the same must accompany all shipments. All stock received from other states must bear a certificate signed by State or government inspectors.

Iowa.—Quarantine may be established against dangerous insects and plant diseases by the State Entomologist at Ames, Ia. Nurseries are inspected at least once a year and certificates issued accordingly. It is unlawful to bring nursery stock into the State unless accompanied by proper certificate from an authorized official.

Kentucky.—The nurseries ot the State are inspected at least once a year by the State Entomologist at Lex-

ington, Ky. Certificates are issued when the stock is found in good condition, and whenever a nurseryman sells trees, vines, plants, or other nursery stock, he shall attach to each package a certificate signed by himself, stating that the contents has been examined by a properly certified official and found free from San José scale and other destructive and injurious insect pests or fungus diseases. All stock shipped into the State must be plainly labeled with the name of the consignor and the consignee by the State or government inspector. Stock arriving without certificate shall be returned to the consignor or inspected by the State Entomologist at the expense of the consignor; otherwise it will be burned.

Louisiana.—It is unlawful to bring into the State nursery stock, pits or any kind of fruit infested with disease or insects of an injurious nature. It is unlawful to propagate or offer for sale any such stock. All fruit trees and other nursery stock brought into the State shall be labeled with the name of the owner or grower, the locality where grown, and shall be subject to inspection by the Entomologist of the Experiment Station at Baton Rouge, La. It is the duty of the owner to disinfect or destroy any fruit trees perniciously affected with disease.

Maryland.—Co-operating under the laws creating a State Horticultural Department, the State Entomologist and State Pathologist are required to inspect once every six months all nurseries within the State and issue certificates to the owners. All nursery stock shipped must be accompanied by a printed copy of the

official certificate attached to each package. Nurseries are compelled to fumigate with hydrocyanic acid gas all stock grown or handled by them under the direction of the State officers. Every package of nursery stock shipped into the State must be plainly labeled with the name of the consignor and consignee and a certificate showing that the contents has been inspected by the proper official. Transportation companies receiving nursery stock arriving into the State without such certificate must send notice to the inspectors at College Park, Md. Failure to return a shipment not properly certified renders the stock liable to seizure and destruction by burning.

Massachusetts.—The Trustees of the Agricultural College at Amherst, Mass., have appointed two inspectors, who inspect all nurseries within the State when called upon to do so. All certificates expire July 1 following the date of issue.

Michigan.—The State Inspector of nurseries and orchards is appointed by the State Board of Agriculture, Lansing, Mich. All orchards and nurseries of the State are properly inspected and certified and certificates issued to the latter. All persons growing or offering for sale any nursery stock within the State are obliged to apply to the State Board of Agriculture and request inspection before August 1 of each year. A deposit fee of $5.00 as a license is required, the license being good for one year and not transferable. Any person, firm or corporation resident of another State shall not engage in the business of selling nursery within the State without first having a proper license

from the State Board. A bond in the sum of $1,000 is required on condition that nurserymen and dealers will comply with all the provisions of the law, and upon demand will file with the Board a list of the persons to whom they have sold or delivered any nursery stock, giving the species, together with the address of each purchaser. Failure on the part of any nurseryman, grower, agent or dealer to comply with these provisions shall render him liable to a fine.

Missouri.—An inspector is appointed, whose duty it is to visit sections of the State and prescribe remedies for diseased trees and orchards. Nursery stock arriving from without the State must be accompanied by the entomologist's certificate, and no package can be delivered until such certificate is attached. The work is under the general direction of the State Board of Agriculture, Columbia, Mo.

Montana.—The State Board of Horticulture shall appoint an inspector of fruit pests for each of the six districts. The nurseries, orchards, fruits, etc., shall be visited regularly and the regulations of the Board enforced. Every person selling or delivering nursery stock is required to notify the inspector at least five days before the said stock is to be delivered, giving date and the nursery and railroad station where the said stock is to be delivered. It shall be the duty of the inspector to inspect such stock, and if any of it is found infested or diseased to order its destruction.

Under the ruling of the Board of the Inspectors at large, inspectors shall inspect or fumigate all nursery stock growing in the State, and shall have authority

to order all nursery stock fumigated with hydrocyanic acid gas or other method. All stock shipped into the State before delivery to the purchaser must be inspected and fumigated as follows: Consignment over the Northern Pacific R. R. from the West, inspected and fumigated at Missoula; over the Oregon Short Line from the South, at Dillon; over the Northern Pacific R. R. from the East, and over the Burlington railway, at Miles City or Billings; over the Great Northern, at Kalispall; over the Great Falls and Canada Railway, and from the East over the Great Northern Railway, at either Glasgow, Chinook, Fort Benton or Great Falls. Any nursery stock brought in on wagons or otherwise shall be inspected and fumigated at the nearest quarantine station.

Importers of nursery stock may have an inspection at any point in the State by paying the expense thereof. All boxes, packages, or wrappings used in importing nursery stock shall be burned as soon as emptied. A fee of $10 shall be charged for each car load to cover the cost of inspection and fumigation. All green or citrus fruits offered for sale in the State shall be inspected, and if found free of disease and infection shall be branded "Inspected and passed." If infested they shall be burned. A fee of two cents per box, with a maximum fee of $5 for each lot inspected, shall be exacted. Every person offering to sell or deliver nursery stock in the State shall place on each package, or car, a label stating whether or not the stock was grown in Montana. General information can be secured from the Secretary of the State Board of Horticulture, Missoula, Mont.

New Jersey.—Any nurseryman or grower of plants offered for sale may require the State Entomologist at New Brunswick, N. J., to examine or have examined the stock grown by him. If no injurious insects liable to spread are discovered he may demand a certificate to that effect. All nursery stock shipped into the State must be accompanied by a proper certificate. Any stock received without a certificate may be detained by the State Entomologist or his deputy, and in case it is found infested it may be destroyed or reshipped to the original shipper. Florists' stock is exempt under this act. Not more than three commissioners are appointed for each county. They are empowered to report the presence of any injurious insects or diseases liable to spread to the State Entomologist, who may order such treatment as seems best. Persons failing to carry out the instructions of the State Entomologist shall be fined.

New York.—The orchards and nurseries of the State are inspected annually under the direction of the Commissioner of Agriculture, Albany, N. Y. Prior to the first of September each year every nursery or other place where trees, shrubs, or plants, commonly known as nursery stock, are grown for sale must be inspected and proper certificates issued to the owner. All nursery stock transported in any manner shall be accompanied by a copy of said certificate attached to each car, box, bale, or package. All transportation companies within the State receiving or carrying nursery stock from any point without the State to any point within shall immediately upon receipt of such consignment notify the Commissioner of Agriculture,

giving the name of the consignor, the consignee, and the point of destination.

If in the judgment of the Commissioner of Agriculture, or his representative, the consignment should be entirely destroyed, such destruction shall be carried on and completed under the supervision of the person in charge. The commissioner shall notify the owner of the trees immediately, giving a brief statement of the facts, and calling attention to the law under which it is proposed to destroy them. In case of objection to the findings of the inspector or agent of the Commissioner of Agriculture, an appeal shall be made to such commissioner, whose decision shall be final. An appeal must be taken within three days from service of said notice and shall act as a stay of proceedings until it is heard and decided.

The recent law passed by the New York Legislature, 1902, requires the fumigation of all nursery stock coming into the State from other States. When fumigated by the consignor a certificate should be attached indicating same. All nurseries within the State located within one-half mile of a district infested with the San José scale must fumigate all their nursery stock before shipment or distribution.

North Carolina.—No person shall sell or give away any trees, shrubs, or woody vines until a license to deal in such plants has been previously obtained from the Commission Controlling Crop Pests at Raleigh, N. C. Certificates previously certified must accompany all consignments of nursery stock, and transportation companies shall not deliver any such stock unless a certificate is attached to each package. All

nursery stock not properly labeled may be seized or destroyed. Transportation companies having nursery stock in their possession not properly labeled or certified shall destroy it or send it out of the State within forty-eight hours, if brought from without the State or otherwise. All licenses to sell nursery stock issued by the commissioner shall bear a uniform date, April 1st or October 1st, and shall be good for six months and no longer.

Licenses to dealers shall be granted to residents of the State, who shall sign an agreement not to purchase nursery stock of any nursery or dealer located within or without the State unless such a nursery is already licensed by the commissioner. Licenses shall be granted only to agents employed by licensed nurseries or dealers, and the principals shall be held responsible for the stock sold by such agents. No fees are charged for licenses, but nurserymen and dealers will be required to pay the actual traveling expenses of the State Entomologist who is sent semi-annually to inspect their establishments. Nurserymen outside the State must send their official certificates properly certified to the Department of Agriculture, Raleigh, N. C. One hundred official tags will be furnished free of charge to the nurserymen filing certificates. Additional tags will cost forty cents per hundred. One of these tags must be attached to each consignment of nursery stock shipped into the State.

Ohio.—Not later than August 15 all nurseries in the State shall be examined annually by the Inspector or his representative appointed by the Agricultural Experiment Station at Wooster, Ohio. If the nurser-

ies appear free from dangerous diseases and insect pests, the inspector shall give each owner of the nursery a certificate to that effect on receipt of $10 for the first day's inspection, and $5 for each subsequent day." Copies of said certificate must accompany all shipments of nursery stock. Every package of nursery stock shipped into the State must be accompanied by a copy of the official inspection certificate. Transportation companies are required to report to the Inspector of a consignment not properly certified.

Oregon.— The State is divided into five quarantine districts by the State Board of Horticulture. All consignments of nursery stock arriving from without the State must be inspected on arrival at the quarantine station. If such stock is found free from pests or diseases, the officer in charge shall issue a certificate to that effect. If any trees are found infested, they are to be disinfected and remain in quarantine until pronounced clean. No peach, nectarine, apricot, plum or almond trees, or other stock worked on peach roots, or pits or cuttings, buds or scions of such-named trees grown in the district where yellows or rosette are known to exist, shall be admitted into the State.

All nursery stock from foreign countries found infested with insects or diseases hitherto unknown in the State are not allowed to land. Nursery stock may be disinfected by dipping into a solution of whale oil soap, or fumigated with hydrocyanic acid gas. All nurseries must be inspected by the quarantine officers of the district in the months of September, October, or November prior to shipment each year. Certificates shall be issued where the stock is found in proper condition.

provided the owner shall fumigate with hydrocyanic acid gas all pear and apple trees, or other stock grown on apple roots after digging and before delivery. General information regarding the control of apple pests may be had by addressing the State Board of Horticulture, Salem, Oregon.

Pennsylvania..—The Secretary of Agriculture at Harrisburg, Pa., shall have all nurseries within the State examined each year. If found free from dangerous insect pests and other diseases, the owner shall receive a certificate. Nurserymen receiving such certificate must attach a copy to each package of nursery stock shipped. Transportation companies shall reject stock not accompanied by such certificate. Nursery stock shipped into the State shall be plainly labeled with the name of the consignor and the consignee, and a certificate showing that the contents have been inspected by State or government officers. Greenhouse stock is exempt under the provision of this law.

South Carolina.—The Board of Trustees of Clemson College designates, every two years, three of their members who constitute the State Board of Entomology. This Board has full power to adopt rules and regulations governing the inspection, certification, sale, transportation, and introduction of nursery stock. The Entomologist at Clemson College, (P. O.), S. C., shall direct the work and inspect each nursery in the State during the months of August and September of each year. Infested orchards shall be treated whenever discovered. The owners of infested orchards or nurseries shall pay all cost for such treatment, except

the traveling and incidental expenses of the entomologist. All nurserymen and dealers in nursery stock located and doing business within the State limits are required to accompany all stock with a copy of the official certificate issued them by the inspector. All certificates are invalid after June 1 of each year, but must be renewed before October 1 of the same year. All persons or incorporations without the State who desire to sell nursery stock in South Carolina shall register their name and file a copy of their certificate of inspection with the Chairman of the Board of Entomology. Upon failure to comply with this, shipments may be destroyed.

Tennessee.—Nursery stock cannot be offered for sale in Tennessee without a certificate from the State Entomologist being attached to each package, as well as the name of the consignor and consignee. Certificates are valid twelve months from date of issue. It is the duty of the State Entomologist to inspect all nurseries and floral establishments when he deems it necessary. All infested nursery stock must be destroyed. Consignments of nursery stock from other States shipped into Tennessee must bear certificates of inspection, as well as the name of the consignor and consignee. Unless a certificate is attached the transportation company receiving same must notify the State Entomologist at Nashville. A fee of $5.00 is required from florists and nurserymen who have less than fifty acres; the inspection fee is $10.00 for nurseries over fifty and less than one hundred acres, and $15.00 for more than one hundred acres. In effect April 20, 1901.

Utah.—The State Board of Horticulture consists of three members, each representing a district. It is the duty of every owner of an orchard, vineyard, or nursery to disinfect trees, vines, or nursery stock if affected with any fruit-destroying disease. All persons who make a general business of spraying trees must first get a certificate from the Board. It is the duty of the Board to have inspected all orchards and nurseries within the State. All persons or nurserymen shall report to the inspectors the receipt of any trees from points outside of the State, and such inspectors shall examine all such stock as well as stock grown or offered for sale in the State. General information can be secured from the State Board of Horticulture at Logan, Utah.

Virginia.—The rules regulating the inspection of orchards and nurseries are made by the Board of Crop Pest Commissioners. No person shall sell or transport any fruit trees or other plants when infested with woolly aphis, San José scale, peach yellows, black knot of the plum, fire blight of the pear, or crown gall. Any nursery found infested with these pests shall not be entitled to a certificate until such pests have been eliminated under the direction of the inspector. It is unlawful for a nursery to offer for sale nursery stock unless accompanied by a certificate of inspection. All nursery stock entering the State from without must be accompanied by a certificate from an official and a competent inspector. The State Entomologist and Pathologist at Blacksburg, Va., shall furnish to all nurserymen in other states doing business in Virginia an official tag upon request, if the certificate of inspec-

tion filed by said nurseryman from without is found satisfactory. Transportation companies can not deliver nursery stock, except when accompanied by a certificate of inspection and the official tag of the State officer. All nursery premises must be inspected at least once a year.

West Virginia.—All nurseries must be examined once a year, not later than August 15th, by the Director of the Agricultural Experiment Station of Morgantown, or by his assistants. Nurserymen are required to pay a fee of $10.00 for the first day's inspection, and $5.00 for each additional day required, before a certificate is given. The certificate is void after August 15th of the following year. Nurserymen must also furnish transportation to and from railway stations to their nurseries. Any person growing trees for sale must apply to the Director for a certificate. All orchards, gardens, and other premises where dangerous pests are supposed to exist, must be examined and given such treatment as may be deemed necessary. All nursery stock from other States must be properly certified, and plainly labeled with name of consignor and consignee. In effect May 16, 1901.

Wisconsin.—The law in this State requires that all nursery stock entering shall bear certificate showing that it has been properly inspected, and is apparently free from San José scale and other injurious insects or plant diseases. The inspection is in charge of the Agricultural Experiment Station at Madison, Wis.

CHAPTER XXIII

FOREIGN LAWS REGULATING SHIPMENTS OF FRUITS AND NURSERY STOCK

THERE have been so many laws enacted in foreign countries regulating the importation from America of all plants commonly called nursery stock, it is expedient to give briefly an abstract of the regulations adopted by these countries. These statements will serve as a guide to nurserymen and others who contemplate exporting nursery stock and other supplies.

Austria-Hungary.—By a decree April 20, 1898, prohibits importation from America of living plants, grafts and layers and fresh plant refuse of every kind if on examination San José scale is found. It also includes the barrels, boxes, and other coverings in which such goods or refuse may be packed. It embodies fresh fruit and the refuse of fresh fruit, as well as the packings which may cover the same. Admission limited to Bodenbach-Tetschen, Trieste and Fiume. Also prohibits transit of infested goods through the Empire.

Belgium.—Importation and transit of fresh fruits, living plants, and fresh parts of plants from the United States can be made only by way of the ports of Antwerp, Ghent, and Ostende, upon production of a certificate from a competent authority asserting that products are not infested by San José scale. If not accompanied by certificate, the products can not be

delivered until inspected. If found infested they must be destroyed with packings. The cost of all services at the expense of the importer. This order went into effect March 15, 1899, but does not apply to shipments in direct transit by railway under supervision of custom authorities.

British Columbia.—Rules and regulations, published June 25, 1897, under the authority of the Horticultural Board Act, 1894, provide that all importers of nursery stock, trees, plants, or fruit must give notice upon arrival, and before removal from wharf or station, to a member of the Board or to the Inspector of Fruit Pests, who shall inspect the same and, if clean, issue a certificate which shall be good for three months, unless revoked by further inspection. Nursery stock found to be infected shall be disinfected or destroyed. Fruit found to be infected shall be destroyed or reshipped.

Canada.—According to the San José scale act, March 18, 1898, Canada prohibits importation of nursery stock from the United States, Australia, Japan, and Hawaii. Stock imported in violation of the law will be destroyed, and the importer is liable to a penalty of $200 for each offense, prescribed by Section 6 of Customs Tariff. The following exemptions are made: Nursery stock of all kinds can be imported from Europe without fumigation, as it is supposed the San José scale has not gained a foothold in European countries. Certain other plants, not liable to the attack of the San José scale, are also exempted from treatment under this act. These are: (1) green-

house plants, including roses in leaf which have been propagated under glass; (2) herbaceous perennials, including strawberry plants; (3) herbaceous bedding plants; (4) all conifers; (5) bulbs and tubers.

As all vegetation is much earlier in Oregon and Washington States, from which most shipments are made into British Columbia, it has been arranged that for that province the fumigating house shall be kept open for the winter months from October 15 till March 15. For Manitoba and the Eastern Provinces the spring season is from March 15 till May 15, and the autumn season from October 7 till December 7.

These fumigating houses are located at the customs ports of St. John, New Brunswick; St. John's, Quebec; Niagara Falls and Windsor, Ontario; Winnipeg, Manitoba; and Vancouver, British Columbia. The whole expense of these stations is assumed by the Dominion Government, but all shipments are made entirely at the risk of the shippers or consignees, the government assuming no risk whatever. The packages must be addressed so as to enter Canada at one of the above-named ports of entry, and the route by which they are to be shipped clearly stated upon each.

Cape of Good Hope.—Regulations published March 25, 1896, under authority of act No. 9, dated 1896, prohibits importation of any stone-fruit tree, or any fruit, scion, cutting, graft, root, or seed, the growth or produce thereof, from the United States, and any one importing such article as aforesaid shall be subject to a fine not exceeding £100 sterling or six months' imprisonment, and, in addition, the articles will be destroyed. It is likely this will be modified, especially

for states in which neither peach yellows nor peach rosette exists.

France prohibits, decree of November 30, 1898, entry into and passing through France of trees, shrubs, products of nurseries, cuttings, and all other plants or parts of living plants, as well as fresh débris from them, from United States, directly or in storage, as well as cases, sacks, etc., used for packing. Also prohibits fresh fruit and débris, when examination proves presence of insect at entry into France.

GERMANY.—A decree of February 5, 1898, prohibits importation of living plants and parts of living plants from America, and barrels, boxes, etc., used for packing. Also fresh fruit or fresh parts of fruit when examination at port of entry shows presence of San José scale. Imperial chancellor authorized to grant exceptions.

By commercial agreement July 10, 1900, this was amended by annulling the regulation providing that dried or evaporated fruits from the United States be inspected. Such fruits are now admitted without other charge than customs duties, and may be admitted at the boundary at the following places:

Prussia.—Main customs offices at Eydtkuhen, Pillau, Danzig, Liebau, Aachen, inclusive of the customs inspection office in the depot of Templerbend, and the freight depot of Roth Erde; Emmerich, inclusive of the two steamship inspection offices, and the customs inspection office located at that place; Kaldenkirchen, inclusive of the customs inspection office at the depot at that place; Geestemünde, Flensburg, Hadersleben, inclusive of the sub-customs office 1 Woyens; Kiel and

office at the depot in Luxemberg. Also main tax offices at Königsberg i Pr. and Stettin, and subcustom offices at 1 Oderberg, 1 Ziegenhals, 1 Halbstadt, 1 Seidenberg, Herbesthal, Bentheim, Borken, and Weener.

Bavaria.—Main customs offices at Lindau, Passau, Simbach, and subcustoms office at Schärding a. Th., and Furth a. W. Also subcustoms offices at Kufstein, Salzburg, Eger, Obernzell, and at the depot of Eisenstein.

Kingdom of Saxony.—Main custom offices at Zittau and Schandau; subcustoms offices at Bodenbach and Tetschen, Voitersreuth, Reitzenhain, and 1 Warnsdorf.

Württemberg.—Main customs office at Friedrichshafen.

Baden.—Main customs offices at Konstanz, the depots of Schaffhausen and Waldshut, and at the depot of Basel; main tax office at Singen and Seckingen, and subcustom office at Erzingen.

Oldenburg.—Subcustoms office at 1 Nordenham.

Lübeck.—Main customs house at Lübeck.

Bremen.—Ports of entry at Bremen and Bremerhaven.

Hamburg.—Quay office, Hamburg.

Alsace-Lorraine.—Subcustoms offices at Fentsch, Amanweiler, Novéant, Chambrey, Deutsch-Avricourt, Altmünsterol, Basel, Markirch, Saales, Diedolshausen, and Urbis.

Netherlands.—By decree of May 23, 1899, prohibits importation and transit, direct or indirct, of live trees and shrubs, or live parts thereof, produced in America, including boxes, casks, baskets, sacks, vessels, and other articles used for packing, unless accompanied by certificate issued by consular officer of Netherlands or competent authority in port of shipment, and objects shall not be landed unless certificate is satisfactory to receiver of import duties.

The following exceptions are made: (1) Importations from countries bordering on the Netherlands in which measures have been taken for combating the San José scale; (2) importations for scientific purposes; and (3) to meet requirements of frontier commerce.

New Zealand.—The act of 1896 prohibits importation of fruit of any kind infested with fruit-flies. Fruit infested with codling moth will be destroyed unless immediately reshipped. Fruit, plants, trees, cuttings or buds infested with any scale insect will be admitted only when accompanied by certificate. Otherwise it will be fumigated at expense of importer or destroyed.

Imported fruit admitted only at Bluff, Dunedin, Christchurch, Wellington, and Auckland.

Live plants admitted only at Dunedin, Christchurcn, Wellington, and Auckland.

Fumigation performed only at Dunedin, Christchurch, Wellington, and Auckland.

Switzerland.—Prohibits plants; prohibits importation of fresh fruit from America, except through Customs Bureau at Basle, where it is subject to an examination by an expert for San José scale or other

parasites. No restrictions to direct importation of dried fruits.

Turkey.—In 1899 it was stated that the imperial government had decided to interdict the importation of trees, plants, and fruits coming from the United States. The writer has made every effort to obtain copies of the decree, but has been unable to secure anything more definite than the above.

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